RESEARCH MEMORANDUM

SOME SPECIFIC SUGGESTIONS FOR ACHIEVING EARLY NON-MILITARY DEFENSE CAPABILITIES AND INITIATING LONG-RANGE PROGRAMS

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Assigned to ______________________

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PREFACE

This research memorandum presents my specific suggestions for measures to be taken in the non-military defense of the United States. These measures are derived from a study sponsored by The RAND Corporation with its own funds as part of its research in the public interest. The findings of this study were recently described in a general summary report.(1)

To acquaint readers of this research memorandum with the character of the full study, summaries of the component parts are included in the appendix. There are some differences in emphasis between the specific summaries in this research memorandum and those given in the general summary report. The specific summaries contain the technical findings and conjectures of individual research workers. The summary report is not only less detailed but represents a broad (though still incomplete) agreement among all who worked on the project. Neither publication necessarily reflects the views of The RAND Corporation. The first two parts of this research memorandum reflect my own views, much influenced by those of my co-workers.

In addition to providing much general orientation on the subject of non-military defense, the study produced two major results: First, it showed that current knowledge regarding many problems of defense measures is too inadequate to serve as a basis for large-scale expenditures. For this reason it is suggested that a rather broad $200 million program of research, development, and planning be implemented to clear up some of these problems so that intelligent decisions can be made, without necessarily increasing the lead time for any large program that is finally adopted. Second, it indicated that a relatively cheap program (costing approximately an additional $300 million over 2 years) might provide us with a valuable

early capability for saving lives and protecting property from bonus and contingent damage, as well as facilitate our ability to recuperate from a war. This "cheap" program would not only be valuable in itself but would bequeath a legacy to any later and larger program that might be adopted.

In addition to the individuals whose work is given in the Appendix, I would like to thank Bernard Brodie, Robert Grosse, Jack Hirshleifer, Hubert Moshin, Russ Nichols, Charles Sandoval, and Leonard J. Savage for helpful comments and ideas.

Many people in government agencies have also been of assistance in furnishing information and orientation. While it would be impossible to list them all, the assistance of the following should be acknowledged: Federal Civil Defense Administration--John Devaney, Gerald Gallagher, Jack Greene, Ralph Spear, Benjamin Taylor; Federal Reserve Board--Roland Robinson; Naval Radiological Defense Laboratory--Walmer Strope, Paul Tompkins; Office of Defense Mobilization--Joseph Coker, Brig. Gen. Harold Huglin, Burke Horton, Vincent Rock, Charles Sullivan; Science Advisory Committee--Spurgeon Keeney. Of course, none of the above are responsible for any portion of the study.

The "attacks" considered in evaluating various non-military defense measures should not be construed as estimates of enemy offense capability or US defense capability. They are hypotheses about threats that appear conceivable, some time in the future, and which provide a measure of the possible role of non-military defense systems.

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I. EIGHT SUGGESTIONS

This study proposes that the government initiate a program costing around $500 million to achieve the following objectives:

1. Research and development should be undertaken on all aspects of the state of the art of non-military defense. Unlike research and development on military matters, non-military defense has received comparatively little money and effort. In particular, this study indicates that imaginative work would not only result in large improvements in the effectiveness of defense measures but would uncover many unsuspected problems that might otherwise cause very unpleasant consequences.

2. Alternative non-military defense programs should be specified. Each program should be balanced. Each should be detailed enough to be costed and to permit the performance to be calculated over time under various circumstances. The specifications should consider time-phasing.

3. After objectives 1 and 2 have been accomplished, the proper balance between military and non-military expenditures should be studied. The government would then be able to make much wiser decisions than it now can, and some of the difficulties resulting from a combination of ignorance and uncertainty would be eliminated.

4. Paper planning and design should be undertaken for a number of the alternatives specified in objective 2, so that any program finally adopted would be less costly and its lead-time would be reduced by 2 to 5 years).

5. Inexpensive preparatory actions, which could result in the creation of very important capabilities in the 1965-70 time period, should be studied. If and when such actions are found to be desirable, they should be put into programs. It appears that some capabilities can be bought for one-tenth the price if they are ordered 5 to 10 years in advance.

6. Modest but worthwhile capabilities should be created by reorienting and strengthening the current civil-defense programs. Some very cheap measures might save from 10 to 50 million lives, limit the contingent damage to property, and markedly facilitate our ability to recuperate.

The program, suggested for achieving the above objectives, is embodied in eight suggestions. They are concerned with--

1. Reorienting government planning--both military and non-military--to the proper kind of short and long wars. (Cost, included in item 4, below, about $10 million.)
2. Reorienting current stockpile programs to contribute to non-military defense and recuperation. (Cost unknown.)
3. Reorienting and strengthening current civil-defense programs to obtain valuable though incomplete capabilities. (Cost about $300 million.)
4. A broad program of research, development, systems analysis, planning and design. (Cost about $200 million over a 2- to 3-year period.)
5. Study of a War Damage Equalization Corporation (WDEC) or similar institution. (No cost.)
6. Initiation of intensive research and other initial steps for a mine (shelter) program. (Cost included in item 4, above.)
7. Technical education and assistance to orient and encourage private planning and research. (No cost.)
8. Independent long-range planning in non-military defense. (Cost, included in item 4, above, $10 million.)

Each of these suggestions is discussed below.

1. REORIENTING GOVERNMENT PLANNING

It is reported that the government is now spending $10 million a year on mobilization studies. Until recently nearly all of these studies have assumed a war involving an initial exchange of a large number of thermo-nuclear weapons, after which the US would mobilize a multimillion-man army to send overseas. Few people defend this picture of a future war; indeed, calculations indicate that it is unreasonable.

Our first suggestion is that government planning be reoriented. In place of the old mobilization base for producing war goods we should have what we have called the passive-defense "Starter and Recuperation Set" (discussed below). We expect the first phase of an all-out thermonuclear war to be short. Because the outcome may be settled in a matter of days, government goals should not be directed toward restoring war production but toward protecting civilians, aiding their survival, and rebuilding the economy, not because any of these activities would aid the war effort but simply because the preservation of people and property is a major responsibility of government.

The Starter Set

By 1960 the United States should have a gross national output in the neighborhood of $500 billion and a construction industry with an annual capacity of $100 billion. Both of these are expected to increase by about 50 per cent by 1970. There are, today, large government and civilian stocks of goods. By suitable preplanning and stockpiling, it should be possible to use these assets as they are (or by supplementing them with additional stocks) to provide a capability for reacting to a slowly deteriorating international situation by quickly producing a balanced system of non-military defense, including shelters.

We have looked into two ways of obtaining this capability. The first, which we call the "Cheap" Starter Set, and which we believe should be implemented immediately, is a program of research, development, systems analysis, planning, and design. The Cheap Starter Set might cost about $200 million over a 2- to 3-year period (see suggestion 4, below, and Sec. II) and could reduce conventional lead-time to permit the execution of an adequate program in 2 to 5 years.

The second approach, which would probably cost in the range of $4 billion to $20 billion, would be aimed at providing a capability for achieving a quite adequate civil-defense program in a year or two. This would include large-scale stockpiling in addition to research and the use of existing assets. Starter Sets of this magnitude are, for the present, recommended only for study, not for implementation.

Recuperation

What if the war comes so suddenly that we have no chance to use either Starter Set? We must then be adequately prepared--in advance--to provide necessities for those who survive and to restore the economy to prewar levels. The Office of Defense Mobilization (ODM), the Federal Civil Defense Agency (FCDA), and the Business and Defense Services Administration (BDSA), have all made faltering moves toward studying survival, but they have done little or nothing on recuperation. Much more needs to be done to ensure that recuperation is both possible and expeditious--and this will require analysis, both survival and recuperation planning, and some measures of preparation. Either Starter Set can be designed to contribute to recuperation after a surprise war--the small one by including in the programs plans for exploiting the resources and stockpiles we already have; the large one by stockpiling with an eye to joint use with recuperation.

Military Programs

Military agencies have often assumed an abbreviated (less than 1 day) first phase of the war and have then often anticipated a recovery of our war-making ability in a very short time. While the second assumption is rapidly being abandoned, the first is still widely accepted.

It would help if the need for planning on the basis of more plausible contingencies were more fully recognized. We are hoping that our study may serve as a guide to agencies concerned with these problems.

Other Wars

Limited conflicts and wars with conventional (non-atomic) weapons are possible. However, as far as our economy is concerned, we are well prepared to fight a war of attrition in a large conventional or even limited nuclear war. Under the threat and increased tension of a small war (in which the strategic force of neither side was yet committed) nearly everyone would be willing to build shelters even at the cost of some war production. Under just such circumstances our Starter Set would be most useful. The Recuperation Set would also be more valuable because the probability of an all-out war would have been increased.

2. REORIENTING CURRENT STOCKPILE PROGRAMS

The Cheap Starter and Recuperation Set envisions the use of existing assets, including government-owned stocks. These might be made more useful very inexpensively by selective processing, relocation, and protection. The government-owned stocks include strategic-materials stockpiles (procurement cost about $7 billion), war-reserve machine tools (procurement cost about $4 billion), obsolete military stocks (procurement cost in the billions),

and commodity-credit food stocks (procurement cost about $6 billion). At a minimum, the government should not dispose of these stocks without first considering the contribution they might make to a non-military defense program.

3. REORIENTING CURRENT CIVIL-DEFENSE PROGRAMS

We have been spending about $50 million to $100 million a year on civil defense. Mounting public concern may result in small increases in this budget, but such increases, if spent in customary ways, will not provide any significant increase in our capabilities. Significant capabilities could be obtained even with small budgets ($200 million to $300 million) if realistic plans were made. Realism in this case means not trying to do too much and, as a result, failing totally, but rather trying to get those capabilities that might be useful in special circumstances even if the range of circumstances is not complete.

A "cheap" civil-defense program is outlined in the Mann study summarized on page 79. It includes a strategic and tactical evacuation capability, fallout protection, radiation meters, use of current inventories, a better public-warning system, and, given these others, a public education program to encourage and aid people in making private plans. We estimate that this program could save from 20 to 50 million lives in some--fairly likely--circumstances.

The above program is one of reasonable cost with valuable, though incomplete, capabilities. Such a program would give real purpose to the work of FCDA and ODM, and raise the morale of the people who have hitherto been faced with the impossible task of preparing to save our lives and industries under any and all circumstances--without spending any appreciable sum of money.

4. A BROAD RESEARCH, DEVELOPMENT, SYSTEMS ANALYSIS, PLANNING, AND DESIGN PROGRAM

Our major recommendation is to spend about $200 million, over a 2- or 3-year period, on research, development, analysis, planning, and design of components of a civil-defense program. How such an amount might be allocated--project by project--is suggested in Sec. II.

We believe that $200 million is a reasonable sum of money to spend on finding out how best to secure the lives and property of the nation. We regard the proposed research program as a mandatory precondition to the decision to spend or not to spend any large sums on passive defense itself.

Is $200 million an unreasonably large sum? It costs from $50 million to $100 million to develop an engine for a military airplane. It costs $100 million to $200 million to develop an interceptor aircraft, $500 million to $1 billion to develop an intercontinental bomber. The ICBM development program cost between $1 billion and $2 billion. The Department of Defense spends $5 billion every year on research and development. We are suggesting that a complete non-military defense program is at least as complicated as an interceptor aircraft.

Some people are suggesting the immediate initiation of large-scale passive-defense programs costing in the neighborhood of $20 billion. It is improbable that large sums could be spent efficiently on construction in the next year or two; it is almost certain that if the attempt were made without a prior program of the sort we are suggesting, not only would the wrong types of personal protection be procured, but there would be major, maybe disastrous, inadequacies and lacunae in the over-all program.

We do not preclude the possibility that some inexpensive measures could be taken during the course of, and based on the results of, the research

program. For example, circumstances might suggest our going ahead with a larger Starter Set--including procurement of such materials as appear most likely to cause bottlenecks in a larger program: reinforcing steel, corrugated steel, structural steel, cement, and other building materials. If this were done, there would be no lag in the completion date of even the largest programs, even if no major construction were initiated immediately.

We believe that a decision to go ahead or not to go ahead on a multi-billion dollar program should be made separately from and subsequent to the completion of the proposed $200 million research program.

Addressing ourselves for the moment to the proponents of large programs, there is at least one good reason why the government may be reluctant to make a commitment today for shelters. Not only has the shelter program itself not been looked at except in a superficial way, but most of the other problems associated with preserving a civilization and a standard of living have not been looked at even superficially. While our study tried to survey these over-all problems--and in particular to ask the question, "How would the country look 5 or 10 years after the war as a function of various preparations?" --we have scarcely scratched the surface. We believe we have shown that it is very plausible, at least in the immediate future, that with cheap measures the United States would be a pretty good place to live in even a year after the war. However, we concede that the uncertainties are great enough to raise the question of sheer survival. The problem becomes more severe in the later time periods. Until the feasibility of recovery is settled, it will be difficult to arouse real interest in attempts to alleviate the consequences of war. We are suggesting that it is possible to settle these questions relatively inexpensively and at the same time to

avoid delaying the completion date for a complete program or the immediate acquisition of moderate capabilities.

5. INITIATE SERIOUS STUDY OF A WAR DAMAGE EQUALIZATION CORPORATION (WDEC)

After an attack, the government would have the responsibility, among other things, for (a) ensuring the monetary viability of the economy, i.e. seeing that banks, other financial institutions, and possibly businesses were not forced to halt operations because of paper insolvency, and (b) distributing property losses among firms and individuals in some fashion more equitable than distribution according to the happenstance of the attack. In some sense, both of these functions are a form of insurance against war losses, extended by the government to its citizens. The ability of the government to carry out these tasks would be increased by the adoption of preattack measures aimed at increasing the amount of wealth that would survive the attack and at speeding up the process of economic recuperation. Our proposal is to find some way to induce people and corporations to pay something toward this insurance <u>before</u> the attack, the money to be spent on long-range civil-defense measures that would enhance the ability of the economy to recuperate after the attack.

We use the term "War Damage Equalization Corporation" (WDEC) to refer to the institution(s) that might carry out all of these functions. A careful analysis is needed of how such a corporation might be financed and operated, and of its preattack and postattack functions. Some preliminary notions may be set down here. In general, the WDEC would raise money from general taxes or sell some type of insurance, on a compulsory or voluntary basis, to firms and individuals. In return, it would be giving them at least some minimum of economic security in the postattack period (just how much security would

depend, of course, on what the country could afford, i.e., on how much of the economy would survive and, if the insurance were voluntary, on how much inducement would be needed to sell it).

Our main interest in the proposal is that it seems to be a way to raise money outside the federal budget. Thus a number of measures that the economy probably could and should adopt--such as creating a preattack mobilization base (passive-defense Starter Set), sheltering industry, stockpiling, planning postattack recuperation, etc.--might be financed. Without the WDEC, funds for these measures might not be forthcoming at all, or, if voted by Congress, might be taken at the expense of other vital programs (limited-war capability, foreign aid, etc.). In addition, the functioning of the WDEC could have some desirable side effects. For example, the rates charged in areas most likely to be attacked could be higher than elsewhere, providing a stimulus for economic dispersal. Beyond this, the mere promotion and sale of WDEC "insurance" would be educational: it would serve to encourage dispersal by drawing the public's attention to the added risk of locating in likely target areas, and it would inspire people to take both a more realistic and a more constructive attitude toward the postwar world. On the basis of Senate hearings on public demand for war-damage insurance, current sales of fire insurance, and the war-damage-insurance experience of World War II, we think that a voluntary insurance scheme might raise upwards of $2 billion a year; a compulsory scheme would raise even more. Of course, these are very rough guesses. Presumably, no large-scale expenditures of funds by the WDEC for civil defense would start until the results of our proposed research program had become available.

6. MINE PROGRAM

Among the more important tasks of the research program will be the investigation of the civilian use of mines, both in war time and in the postwar period, as personnel shelters and as industrial and storage sites. Our study has already shown the value of mine space for these purposes, particularly in meeting the potentially large attacks of the late sixties, although much detailed investigation remains to be done. However, some useful steps can be taken immediately and at small cost that would enable us to evaluate better how much mine space could be made available in the late sixties and to ensure that such space would be available.

Mine space can be more or less expensive, depending on the way we go about obtaining it. If underground space is sought in a hurry, it will be very expensive. (Conventional excavation is generally three to ten times as expensive as mining the same amount of material. In addition, the miner sells his product, whereas the conventional excavator either dumps it or at best sells it at a very low price.) Our preliminary investigations have indicated that by paying a small premium to the mining industry, particularly but by no means exclusively limestone mining, it would be possible to create suitable underground space very cheaply in advance--in most cases where it is wanted and in all cases as it is wanted. The necessary premium might be in the range of 25 to 75 cents a square foot. The same, or a slightly larger, premium might be sufficient to shift, say, 20 to 30 per cent of the open-quarry operations underground.

If further investigations indicate that our preliminary look is correct, the government should initiate a program to encourage the creation of mine space.

Probably the most innocuous way to create mine space would be to start by negotiating DPA-type* contracts with a few mine or quarry operators. These contracts would put a floor under the price of a specified amount of suitable mine space. This floor price might range from close to zero to at most $1.00 a square foot. Our belief is that when the time came for the mine operator to sell this space, he would find that there were other purchasers willing to pay much more for it, and the program would end up costing the government nothing directly. In any case, the maximum possible cost involved in starting the program would be small, and it is important to get a feel, as soon as possible, for how successful a large program might be. Our own estimate is that in the early period we might easily get 100 to 400 million square feet a year in a large program, and in later periods, more.

The Panero study (page 77) indicated that there might be 750 million square feet of suitable mine space available today. Other RAND studies have indicated that some of this space might be valuable for military installations. In addition, our preliminary study indicated that some kinds of peacetime operations are actually cheaper when conducted in suitable mines than when pursued by more conventional methods. In fact, there already is a small trend in this direction, which the government should accelerate if it can. Either the military or the civilian possibilities might put the government in the market in the immediate future for a small part of the available space. It is important that the government buy space without setting precedents that will cause the space to be overvalued. Condemnation is usually a poor way to acquire property because it generally

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*Defense Production Act. Under this act the government stimulated machine-tool manufacturers to increase production, even before they had orders, by guaranteeing the manufacturer a minimum market.

results in high costs and because its windfall character does not encourage the creation of more space. It is probably best to buy mines on a bid basis or by contracts negotiated before the space is created.

An important benefit from a mine program would be that all mine operators everywhere would realize not only that mine products are valuable, but that the mine space itself is also potentially valuable. All of them would then presumably undertake at least some of the cheap things that can be done both to create more mine space of the proper sort and to preserve the mine space currently available. At present, mines are often allowed to deteriorate because their owners do not realize their potential value. Probably some hundreds of millions of square feet have been wasted as a result of such neglect.

7. TECHNICAL EDUCATION: ORIENTING AND ENCOURAGING PRIVATE PLANNING AND RESEARCH

Once the research program has provided some indication of what a reasonable passive-defense program should involve, the government should enlist the help of private groups to expedite some of the necessary intellectual and technical developments. Some of the professional and other organizations whose aid might be solicited include:

American Society for Civil Engineers
American Concrete Institute
American Bar Association
American Medical Association
American Institute of Architects
National Planning Association
Committee for Economic Development
Chambers of Commerce
National Bureau of Economic Research
American Association of Railroads
American Society for Testing of Materials
American Society for Mechanical Engineers
American Society for Electrical Engineers
American Society for Heating and Ventilating
National Association of Manufacturers

In the past, private groups have sometimes put time and energy into studies for the government, but a lack of adequate orientation has often meant that their studies become obsolete before they were started. It is important, both for the morale of the participants and the usefulness of their product, that realistic environments and planning assumptions be given to such groups. For example, the American Society of Civil Engineers (ASCE) is reported to be considering a standard for the protection of buildings in large cities, on the order of 5 to 10 psi. Such buildings might not be useless in some situations, but they would certainly be useless if bombs were dropped nearby. We propose that a much more useful activity for the ASCE would be to investigate a joint-use blast-resistant construction for small cities and rural areas rather than for large cities. An even more important undertaking, and one which we urge be done with a high priority, would be to determine the possibilities for joint-use fallout protection, both with and without warning (hours or days). For example, buildings might be designed so that sandbags or shutters could be put up at the last moment. Either of these measures would greatly decrease the vulnerability of their occupants to radiation. We feel that the possibilities are so promising that an appreciable portion of an expensive fallout program might be saved (though only a portion). It is clear there are many other examples of the usefulness of private organizations.

Much can also be done by private individuals and businesses. Some of the preceding suggestions are aimed at making it possible for the government to furnish realistic technical information and planning assumptions to individuals and businesses so that those who wished to, could do sensible things on their own. We feel that at least part of the present apathy in the

United States is due to ignorance of what can be done and to doubt that anything can be done. This apathy is intensified by the inadequacy of official pamphlets. The problem does not result from security restrictions or from insufficient release of information but from the inadequacy of the official studies themselves. Better studies and more definitive government programs are needed. Realistic long-range planning, such as we are proposing, would go far toward restoring public confidence in the merits of government plans and suggestions. Even more effective would be the institution of the "cheap" program, which depends mainly on improvised fallout shelters. Such a program would encourage many to build more adequate shelters on their own. As long as there is no reasonable over-all program, few will undertake private actions.

8. INDEPENDENT LONG-RANGE PLANNING IN NON-MILITARY DEFENSE

It is now conventional for the military to plan 5, 10, and even 15 years ahead. Such plans must often be scrapped as views of the future change; but good or bad, it is essential to do such planning. Even poor planning is sometimes better than none, because the planning process itself is educational. In any case, almost all military planners try to keep ahead of the newspapers and the annual budget crises. It was a great shock to the writer to find that there is almost no such full-time activity on the civilian side of the government. There are occasional committees that meet for a few months, or a few government employees having some planning responsibilities, but the latter tend to have little time or capability and their staffs are inadequate.

The writer has found that operations-analysis organizations having hundreds of members, many of them quite competent, are just barely able,

working full time, to keep abreast of current military developments; only rarely do they successfully initiate detailed long-range planning.* Moreover, almost every good study put out by such organizations has taken about 2 years to do and has depended a great deal on having many experts within each field available (so one can play them against each other--it seems to be a deadly mistake in this field to tap only a single expert in any particular area and to take his advice verbatim).

The output of these operations-analysis organizations is not uniformly good. We have discussed some of the reasons why this is so in another study.[(2)] However, we know of no other environment in which it is even conceivable to do long-range relatively complete studies of complicated subjects such as the non-military defense of the United States. And such studies should be done.

Several of our proposals called for more long-range planning by the staffs of various government agencies. It is not being suggested here that the operations-analysis organizations are a substitute for this long-range planning on the staff level, only that it be supplemented by "independent" planning on an adequate scale.

If the WDEC is instituted, it might be a very reasonable place to house the long-range planning organization for the passive-defense field, or, to

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*One difficulty can be illustrated by considering that in the last 12 years since Hiroshima, weapon yields have increased by about three factors of 10. Each factor of 10 means a revolution in technology that should also imply a correspondingly radical change in the plans. The situation is aggravated by the almost equally spectacular changes in the relations of offense and defense capabilities. The long-range planner who is trying to think a mere 5 to 10 years ahead (barely enough time to get a program in, and much too short a time to amortize it) must be two or three revolutions ahead of the contemporary situation. In real fact, he is usually one or two revolutions behind.

be more ambitious, <u>one</u> of several long-range planning organizations in the passive-defense field. Some "duplication" and competition in long-range planning and analysis is highly desirable.

II. A BROAD RESEARCH, DEVELOPMENT, AND PLANNING PROGRAM

Probably the most startling of our eight suggestions is that we spend about $200 million over a period of 2 or 3 years on what might be called the preliminary phases of a civil-defense program--mostly on research, development, analysis, planning, and design. These preliminaries (which we call the "Cheap" Starter and Recuperation Set) should not be restricted to any prechosen program. The scale of the final program would presumably be determined by the results of these investigations and by the current international situation. It should not be fixed prematurely. It is also most important to consider explicitly a time period in the late sixties and early seventies. Unless we start soon, the long-range programs needed to ameliorate the effects of potentially very destructive attacks of this time period, we will find that we have lost very valuable opportunities.

Our main goal in allocating funds to projects was to make sure that every major problem area was adequately covered. Our final figure of $200 million is, of course, very approximate; but we suspect it is as likely to be low as high if an adequate job of research, development, systems analysis, planning, and design is to be done. Many of the potential civil-defense programs are so expensive that it is worth while to spend some money speculatively if there is any chance at all that the over-all program will be helped by even a small percentage; therefore, the aim should be not to see that every dime is spent with 100 per cent assurance of achieving a successful project, but rather to see that all interesting avenues are explored. Otherwise, there may be disastrous inadequacies, or even complete lacunae, in the program that is finally adopted.

We have deliberately avoided setting priorities among the projects suggested. In the field of non-military defense, as in the field of military defense, we are in a technological and quantitative race with the Soviets. If our relatively inexpensive program is stretched out over 4 or 5 years, we will not only lose 2 or 3 years in an absolute sense, but we will also lose this same amount of time relative to Russian offensive preparations. Given the pace of modern technology, in which revolutionary changes seem to appear every 5 or 6 years, an additional 2- or 3-year lag can be significant. One of the most discouraging things about past government programs in the field of non-military defense is that they have tried to treat even the planning problem in easy stages. As a result, the work was often obsolete before the bare outlines of the first-stage problems were clear.

As a possible case in point, the government has just recently abandoned its interest in the recuperation of heavy industry as a support for the postattack mobilization base to concentrate on light industry in connection with survival studies. This is undoubtedly an improvement. But it is still important to determine how to restore it in 5 or 10 years. While ensuring that people survive the first 2 years is an essential antecedent to restoring heavy industry in 5 or 10 years, very few will look favorably on, or value highly, costly programs the net result of which will be the degrading of U.S. standards of living to Chinese or Indian levels. It is therefore crucial to study all aspects of a complete program, if only to establish feasibility.

The over-all budget is divided into 12 categories:

I.	Personnel shelters	$ 65,000,000
II.	Mines and industrial shelters	15,000,000
III.	Ordinary industrial shelters	5,000,000
IV.	Studies by private industry	15,000,000
V.	Special equipment and processes	15,000,000
VI.	Anticontamination and fallout	30,000,000
VII.	Medical aspects of the shelter program	10,000,000
VIII.	Food and agricultural research	15,000,000
IX.	Expansion of government studies	10,000,000
X.	Academic studies	5,000,000
XI.	Systems analysis and operations research	10,000,000
XII.	Miscellaneous	5,000,000
		$200,000,000

In several categories, e.g., "anticontamination" or "special equipment and processes," we have no real feeling as to what reasonable expenditures are; the numbers are relatively arbitrary. For others, e.g., personnel shelters, mines, and industrial shelters, we think we have a fairly good feel for what the numbers should be. However, in no case did we put in enough work and thought to come up with final figures. The numbers are intended to communicate quantitatively our intuitive and preliminary thinking. They are not specific recommendations for implementation.

On the following pages we present a detailed expenditure breakdown, category by category, and indicate in general what we propose be done under each project heading.

Such a large and many-sided research, development, and design program would require a strong monitoring effort of a type that is not common in most government agencies. This effort would have to be much more than the ordinary R and D administration. It would be necessary for the monitors to maintain a continuous and close observation of all the programs and constantly to evaluate their direction and results. They should be able to suggest the termination of fruitless programs, on the one hand, and to encourage the expansion of promising efforts, on the other. Most important, they would have to be alert to gaps and inadequacies in the programs.

The monitoring group could be located in the independent long-range-planning organization, mentioned under suggestion 8 in Sec. I, and could act for the various government agencies that would be principally concerned with the non-military defense effort (such as FCDA, ODM, or a combination of these). The monitors would not need, and should not have, the authority to orient all programs toward predetermined objectives. Experience has shown that attempts to conduct large and overcoordinated programs tend to create inflexibility and to stifle new, unproven ideas or independent approaches. Hence, the monitors should act as an advisory group rather than as a "research czar." But they must have the authority to make suggestions and to offer criticism at all levels; they must also have the right to contact the researchers or planners in the field. In order to maintain a good feel for the program as a whole and to foresee future requirements, the monitors should be closely associated with the systems analysis and operations research program (see Category XI, below). Perhaps they should also have direct access to experimental research funds for small pilot projects, such as those mentioned in Category X, below. Because of their crucial role, the monitors must obviously be an exceptionally competent and well-informed group of people.

CATEGORY I: PERSONNEL SHELTERS ($65 MILLION)

The $65 million for personnel shelters might be allocated as follows:

1.	Theoretical studies	$ 3,000,000
2.	Experimental program	20,000,000
3.	Basic designs	4,000,000
4.	Detailed study of 10 large cities	11,000,000
5.	Detailed study of 10 medium and small cities	6,000,000
6.	Detailed study of 10 rural areas	3,000,000
7.	Mines as personnel shelters	1,000,000
8.	Cheap civil-defense programs	2,000,000
9.	Construction of prototype shelters	10,000,000
10.	Miscellaneous	5,000,000
		$65,000,000

Theoretical Studies: $3 Million

The $3 million for theoretical work may be high. It is difficult to spend this much money on paper and pencil work in 2 or 3 years. However, we should try. The possible gains are enormous. The major effect would be to increase both our understanding and the state of the art, but the program would surely pay for itself if only because of relatively minor savings in, for example, the better design of experimental programs and improvement in the analysis of experimental data. There ought to be a rule that no experimental work be done unless some theoretical work has been done first, not because theory is necessarily satisfactory, but because it forces one to think about the experiment. The writer has the strong impression that many quite expensive test programs have been initiated with very little prior thought by the sponsors. Sometimes this is unavoidable, but a vigorous program of theoretical work would go far toward increasing the value of the experiments.

In general, we are interested in the response of basic shapes and materials (such as boxes, arches, and spheres) under all circumstances, but particularly when buried. We are also interested in direct earth-induced groundshock for the deep underground structures (such as those we have designed for Manhattan Island), the design of structures for multiple purposes (as described in the O'Sullivan study on page 73), the design of ingenious structures and components (such as pressurized or tension doors and maybe even shelters, structures with blast-protected space separate from survival space, resilient structures, resilient covers for structures), etc. We are sure many other ideas will evolve once a program encouraging imaginative work on a large scale is started.

Experimental Program: $20 Million

A $20 million program is somewhat larger than past programs and it still may be too small. The program should allow for the testing of about ten structures at two tests in Nevada and for a somewhat smaller number in the Pacific, plus a certain number of basic experimental weapon-effects studies and more laboratory studies. This last item may be very important if nuclear tests are banned by international agreement. It is assumed that the current relatively vigorous military program will be continued and that the two programs will be coordinated to some reasonable extent, otherwise the figure is too low.

Basic Designs: $4 Million

To bridge the gap between theory and practice, $4 million is allocated to basic design and architecture, both for the test program and as analytical components of the proposed detailed city and rural shelter studies.

These design studies should include structures for multiple and special uses, ingenious structures suggested by the theoretical work, etc. The final objective should be to develop a menu of standardized designs. An important by-product to be explicitly encouraged by this and the detailed city and rural shelter studies would be the education of engineering and architectural firms in the techniques of protective construction and the general stimulation of imaginative work. The architectural aspects of shelters should be emphasized as much as the structural aspects. We feel that some of the past work has been deficient in this respect--a shelter is more than a box.

Detailed Local Studies (Items 4 - 6): $20 Million

We are proposing to spend $20 million on feasibility and preliminary design studies for the protection of specific areas. A representative list might include 10 large cities, 10 medium and small cities, and 10 rural areas. The detailed allocation might be $11 million, $6 million, and $3 million, respectively. The objective would be to select representative locations and to provide specific designs to exploit or ameliorate the geographic, geological, and ecological features of each site. Our Manhattan study (page 77) is an example of what might be done.

A typical city study might be conducted as follows:

(a) Obtain a number of proposals for about $5000 apiece from interested firms. Because this sum of money is small and the situation is competitive, it is likely that only interested firms would participate.

(b) Have some agency or committee look over the proposals and either pick out the best one or amalgamate the best features of several. Where it seemed desirable, several alternatives might be selected for further study.

(c) Give this interim proposal (or proposals) to some firm (or firms) to make a feasibility check. This might cost about $25,000 per proposal.

(d) If the feasibility study were encouraging, and if we still liked the firm, give it, say, another $50,000 to carry out the preliminary design. This is the stage which should include the question of phasing.

(e) Formally review and approve the preliminary design study. If we were still satisfied with both the firm and the proposal, we could have the firm prepare working drawings or at least final designs that would enable it to make relatively accurate cost estimates, and also permit final design and construction to be started rather easily if that were decided upon.

Legal problems should be studied simultaneously because they are often the most serious bottleneck. All of this might cost $100,000 to $500,000.

The above effort should not only include studies of both adequate and austere shelter systems, but also of the cheap program discussed later (in which very moderate but also very inexpensive capabilities are sought).

The studies should explicitly include such considerations as—

(1) Protection during the emergency (bombing).

(2) Survival space for protection against initial high levels of radiation.

(3) Phasing requirements. It is particularly important that the shelters built early in the program be able to accept extreme overcrowding so that we will have an early capability for sheltering most of the population under very austere conditions. The possibility of having the "cheap" program phase into a "minimal" or more elaborate program (see the O'Sullivan study on page 73) should also be considered.

(4) Capability for improving resistance and habitability of shelters (as a hedge against either the threat's getting worse or the shelter standards' getting better).

(5) Housing and protection conveniently available to a work force (to enable the economy to operate during tense or degraded international situations).

(6) Evacuation housing (particularly important for shelters in non-target areas that would accept evacuees in a strategic-evacuation situation).

(7) Postwar housing and refuge.

(8) Various other prewar and postwar industrial, commercial, and administrative uses of shelters and their sites.

Points (2), (5), (6), (7), and (8) might include the use of unprotected space outside the shelter that could be adapted to the purpose listed. For example, survival space might be provided by an area outside the shelter that could be decontaminated, or by relatively vulnerable portions that were not occupied during the emergency and that, if destroyed, would result in a rescue problem or in discomfort for the inhabitants of the shelter rather than in their death. Similarly, rural shelters might provide relatively comfortable evacuation quarters if the shelter utilities were combined with relatively cheap temporary aboveground facilities. In the postwar world these same utilities, together with some aboveground expansion, could provide inexpensive semipermanent housing.

Mines as Personnel Shelters: $1 Million

In our preliminary studies we examined the feasibility of sheltering people in mines for 2-, 7-, 30-, and 90-day periods. We are allocating $1 million to more detailed analyses of this sort.

The emphasis should be on cheap modifications of the mine that might fit in with its subsequent use as an industrial shelter or warehouse. Other studies should also be made that would consider the mine as a joint-use proposition with an underground industry or with other installations. Many of these mines are very large and could house a number of installations with room to spare. Substantial economies might be realized by such joint use.

Cheap Civil-defense Programs: $2 Million

We have allocated $2 million to the study of the inexpensive civil-defense programs suggested by the Mann study (page 79).

These cheap civil-defense studies would be in addition to the by-products we would get from the studies previously mentioned and should, of course, exploit these latter studies as much as possible. The low figure of $2 million for this program assumes that the money would be used only to finance special studies. Most of the actual field work would be done by the regular civil-defense and other government organizations and is not included in the above budget of $2 million. We believe that with budgets only two or three times larger than the traditional ones, it would be possible to achieve capabilities that in the near time period might be effective enough to save from 20 million to 50 million lives. If the cheap civil-defense program is instituted, then this money should be used to finance parallel studies by persons who are not involved in operational responsibilities.

Construction of Prototype Shelters: $10 Million

The sum allocated for construction of prototype shelters may be much too small. We would not consider the program badly balanced if more were spent. If the cheap civil-defense program is adopted, this money should be mostly spent on "long-range" shelters. If it is not adopted, part of this money should be spent on current cheap shelters. We wish to build prototype shelters partly for educational and psychological reasons (so that people can see them and builders can see how they are built and can suggest improvements, simplifications, etc.) and partly for experimental architectural and structural studies. The experience gained by both designers and builders

would be important. We should also conduct some experiments in which people actually live in these shelters, under both normal and overcrowded conditions. (See Category VII on medical research.)

Miscellaneous: $5 Million

A sum of $5 million has been set aside to meet unexpected contingencies in other categories of research on personnel shelters.

CATEGORY II: MINES AND INDUSTRIAL SHELTERS ($15 MILLION)

As we have already remarked at some length, mines could be useful to us in a number of ways:

Emergency personnel housing and protection, dispersal of people and industry
Emergency warehousing and stockpile storage
Industrial sites, commercial and office space
Permanent personnel housing
Government relocation sites
Military installations and headquarters
Various postwar activities

Some of these uses of mines might be sequential. For example, we might outfit a mine as an emergency shelter for evacuees, use it later for stockpiling, and finally convert it for use as a permanent underground installation of some sort.

We propose to spend $15 million on research into the uses of mines, allocated as follows:

1.	Survey of existing mines	$ 500,000
2.	Survey of existing quarries	250,000
3.	Studies of the economics of mining	250,000
4.	Research to encourage mining and improve technology	1,000,000
5.	Preliminary geological study of U.S. ...	5,000,000
6.	Design of underground industrial installations	3,000,000
7.	Design of underground military installations	1,000,000

8.	Design of underground civilian installations	1,000,000
9.	Design of specialized underground installations (reactors, power stations, etc.)	1,000,000
10.	Centralized agency	1,000,000
11.	Miscellaneous	1,000,000
		$15,000,000

Survey of Existing Mines: $500,000

We know far too little about the nature and availability of underground-mine space but we do know enough to make it appear to be an inexpensive source of protective shelter for personnel, industry, and other types of installations. We need a complete survey of mines, including estimates of the cost of adapting the mine to shelter purposes and information on expanding the space, location of transportation, utilities, and labor force, as well as on other factors affecting the utility of each mine.

Survey of Existing Quarries: $250,000

We are interested in quarries for two reasons. First, they provide a possibility for relatively cheap and fast underground construction (because excavation has already been done); second, and more important, many quarrying operations can be converted inexpensively to tunneling operations. Since most rock is removed from quarries rather than from mines, quarries may be the major source of future underground space. The primary object of the study, therefore, should be to get semiempirical estimates of how many quarry operations can be converted to mining operations, either at their current locations or at new locations, as a function of the subsidies or other inducements that might be offered by the government.

Studies of the Economics of Mining: $200,000

In addition to several theoretical studies of how best to encourage the type of mining operations we are interested in, there might be rather specific studies of definite areas and quarry operations. These studies should also be broad in the sense that they should look at many ways of encouraging the creation of suitable underground space and at radical changes in the industry. For example, we might wish to encourage very deep mining under urban areas.

Research To Encourage Mining and Improve Technology: $1 Million

It is our impression that relatively little money has been spent on research to develop new uses for crushed rock and such products of the mining industry. (If this is so, one reason may be that the industry is quite competitive and it does not pay any one company to do research, since the benefits would accrue to all companies.) We don't know whether this is a fruitful field or not, but we think that at least a million dollars might well be spent in studying ways of expanding the industry, either by improving the markets or the technology. If these studies were even mildly successful, they might make very important changes in our capability. We concede, of course, that some of the studies might be very speculative.

Preliminary Geological Study of the U.S.: $5 Million

This survey will cost only slightly more than $100,000 per state. Also, the states might be induced to do some work on their own. About 10 per cent of the money might be spent on the collection of currently available data and 90 per cent on acquiring new empirical data (including some borings) on the geology of interesting regions. This would not be enough money for a

really comprehensive investigation, but it should yield a great deal of valuable information. We are particularly interested in identifying and describing convenient new sites and marketable rock formations so that preliminary planning for the location of underground sites can be done by referring to files without making field trips. The survey should probably be conducted in two phases: first a quick study to develop information for the other studies, and then a more leisurely one that would attempt to do a reasonably complete job.

Design of Underground Industrial Installations: $3 Million

Considerable pioneer effort by architect-engineer teams is needed to investigate the cost and feasibility of placing various types of industrial and civilian functions (government offices, communication facilities, civil-defense headquarters, etc.) in underground shelters.

We recommend that a preliminary design be made for the underground installation of about ten to twenty factories, probably in cooperation with specific companies. The emphasis should not be on the cost of putting an unchanged aboveground plant underground, but on modifying plants in ways that would exploit the advantages of their being underground and minimize the disadvantages. The study should include all the factors that influence the profitableness of an operation and should not be restricted to just the cost of construction. To do this, the architect-engineer firm should work closely with the people doing relevant industry studies, as described in Category IV, below. We believe that these studies should be conducted in the same sequence as was suggested above for the personnel-shelter studies. This should encourage imaginative work.

Design of Underground Military Installations: $1 Million

RAND studies have indicated that a number of military activities can be advantageously located underground. Since such studies might well be coordinated with the civilian studies, we have allocated some money to do this.

Design of Underground Civilian Installations: $1 Million

The civilian installations that come to mind are mostly government relocation sites, communication facilities, specialized commercial and office space, and possibly civil-defense headquarters or other organizations in the non-military defense field.

Centralized Agency: $1 Million

A centralized agency, with more than routine technical capabilities, is needed to--

(1) Collect and correlate information on all aspects of underground installations from all sources and publish it for the use of all interested groups. It should also conduct an aggressive education program.

(2) Provide free or inexpensive consulting and other technical assistance to government agencies and private organizations.

(3) Monitor government studies and contracts and provide liaison.

This agency might cost about $500,000 a year. It might be located in an existing government agency--e.g., Bureau of Mines, Corps of Engineers, Business and Defense Services Administration, etc.--or it might be in the long-range-planning organization discussed in Sec. I, suggestion 8.

Miscellaneous: $1 Million

Again we have set aside a sum to meet unforeseen needs of other subprojects.

CATEGORY III: ORDINARY INDUSTRIAL SHELTERS ($5 MILLION)

In addition to putting some industrial installations in mines, we may wish to protect others by conventional protective construction either underground or aboveground. Some of the objectives that should be included in the investigation are listed below:

(1) Protection of part or all of the plant. "Part" might include especially expensive or vital equipment or easy-to-protect items such as inventories.

(2) Design and operation of plants so that they would be capable of postattack emergency operation.

(3) Expansion possibilities, with or without use of the Starter Set, of both the protected and unprotected areas.

(4) Protection of an improvable kind.

(5) Operation of plants during a strategic evacuation.

(6) Expansion of plants in rural areas during a strategic evacuation.

(7) Operation and expansion of plants in the postwar world, with some attention paid to radiation problems.

CATEGORY IV: STUDIES BY PRIVATE INDUSTRY ($15 MILLION)

Studies by private industry under contract are needed in addition to governmental studies (by BDSA, ODM, etc.). When competent staffs close to top management in representative key industries cannot be found, projects should be assigned to independent research or consulting firms. Important projects should include:

1.	Inventory studies (20 at $100,000 each)	$ 2,000,000
2.	Reconstruction studies (20 at $100,000 each)	2,000,000
3.	Redesign of plants for shelters (20 at $100,000 each)	2,000,000
4.	Production-adjustment studies (40 at $50,000 each)	2,000,000
5.	Emergency dispersal and new plant (20 at $100,000 each)	2,000,000
6.	Special study of construction industry	3,000,000
7.	Study of communications	500,000
8.	Study of transportation	500,000
9.	Miscellaneous	1,000,000
		$15,000,000

Inventory Studies: $2 Million (20 at $100,000 Each)

After the geographical location of a firm's or industry's inventory by area and product class has been studied, the three following assessments should be made:

(a) Study costs and changes in operations if inventories are increased in non-target areas and decreased in target areas. Include cases in which there is an increase in the total inventory. Consider inexpensive forms of protection and estimate additional need for fixed and working capital and increases in annual operating costs.

(b) Repeat with inventories transferred to specially constructed blast-proof warehouses near the plant. (Fixed-capital costs of such warehouses should be estimated as part of a separate research project on ordinary industrial shelters with designs adjusted to operations of each industry.)

(c) Repeat with inventories transferred to mine shelters in the most suitable available locations. (Locations should be specified by a separate research project on mines or by systems analysis. Again, fixed-capital costs should be estimated in a separate project, but the designs should be adjusted to industry operations.)

Reconstruction Studies: $2 Million (20 at $100,000 Each)

While much work has been done in the field of protection, survival, and immediate patchup, almost no work has been done on the problem of restoring a prewar society. An important part of this restoration problem is the rebuilding and repairing of our industrial plants. The following specific studies are suggested:

(a) Analyze the problem of resuming production in abruptly abandoned plants that did not suffer blast damage but were subjected to fallout. Consider measures to prevent abandonment damage. Plan a decontamination program (in cooperation with the separate research project on decontamination). Estimate fixed-capital costs of preattack preparations that would simplify postattack problems.

(b) Estimate (in cooperation with ODM or other bomb-damage consultants) likely patterns of damage to plants subjected to "substantial" partial damage, plus fallout. Then design an emergency "temporary" reconstruction program that would (1) restore production quickly, (2) use salvaged materials and equipment, and (3) substitute less-scarce for more-scarce materials in the ODM listing. Estimate the cost of materials and equipment to be provided from "outside."

(c) Design a project for new-plant construction, also one for "temporary" plant construction with the same objectives. Again estimate cost of materials and equipment, this time with a comparison of the cost of normal construction procedures. Identify any major plant elements that, if stockpiled or prepared in advance, would significantly speed construction.

(d) Describe the present policy with respect to disposing of obsolete equipment, maintaining standby equipment, storing spare equipment for

repairs, etc. Estimate fixed-capital costs, and annual storage costs, of increasing the amount of such equipment held, and of storing it in "safe" areas.

Redesign of Plants for Shelters: $2 Million (20 at $100,000 Each)

As a supplement and complement to the protective-construction research (both mine and surface shelters), studies should be made of the redesign of plants in key industries so that they can be put underground or in shelters. This would mean economizing on space, using small spans, minimizing ventilation and air-conditioning problems, minimizing noise problems, and exploiting special features of mines. These projects, by concentrating specifically on the annual operating costs of protected plants, should reveal the costs to the economy of alternative protective policies. Ways to induce private firms to carry out these policies might also emerge.

Three types of protective design should be considered (including flexible use, as described above under Category III):

(1) The relocation or the building of new conventional plants in relatively "safe" areas (outside the industrial northeast). Estimate additional annual operating costs of these locations.

(2) A new plant in a specially constructed blast-proof shelter in the fringe areas of cities where such plants would normally be located in the next decade. Estimate additional fixed-capital costs and current operating costs.

(3) A new plant in a mine or new underground site at various available locations. Estimate additional fixed-capital costs and current operating costs.

These studies should include the same objectives, with respect to the flexible use of the plants, as those listed in Category III.

Production-adjustment studies: $2 Million (40 at $50,000 Each)

Two types of studies are proposed. The first would plan the operation of an undamaged plant, substituting less-scarce for more-scarce materials and making intensive use of capital equipment. Hard-to-replace materials, equipment likely to cause bottlenecks, and changes in annual operating costs would be identified.

The second study would plan the rapid expansion of production in existing plants for industries supplying materials and equipment for a crash civil-defense program (such as the "big" Starter Set). Bottlenecks in materials, equipment, and labor, as well as changes in operating costs, would be identified. Special attention would be paid to advance preparations to facilitate the crash program.

Emergency Dispersal and New Plant: $2 Million (20 at $100,000 Each)

A series of plans should be prepared to estimate the capital and operating costs of equipping and operating an emergency plant in an existing building or mine, emphasizing speed and the economy of scarce resources. Savings in time and materials should be measured for various types of advance actions--site preparation, preplanning, and partial prefabrication. Special attention should be given to using government stocks of equipment and machine tools.

Recuperation factors should not be neglected. Where underground or protected-site operating costs are very high, the idea of providing standby plants might be considered. We may be willing to underwrite high operating

costs in the emergency postwar period that would be unacceptable by peacetime standards.

Plans should be drafted for moving essential existing plants (in part or in whole) to one or several dispersal safe sites or mines. Movement and capital costs, equipment and construction costs, and preparation and pre-planning costs should be calculated.

Study of Construction Industry: $3 Million

Perhaps the key to any passive-defense starter set is the readiness and capability of the construction industry. (For the Recuperation Set, its vulnerability and ability to operate and expand in a postwar environment are crucial.) The construction industry is a dispersed, loosely organized industry, and a great deal might be done to anticipate time-consuming problems with a view to expediting any program that might eventuate. While we are describing this as a "study"--and indeed much of what needs to be done consists of collecting information, organizing it, and the analyzing special problems--the most essential part is the drafting of the enabling "paperwork," a task that takes much thought and effort.

For the Starter Set, we would seek to relate the specific needs of a civil-defense program to the capabilities of the industry. To do this we must compile a shopping list of the type, quantity, and source of both suppliers and materials to be supplied. When we have identified contractors, we should consider the kinds of research and shelter make-ups. to be under-taken, standardize plans and contracts, agree on inspection and acceptance procedures, and, finally, attempt to choose and survey sites and to pre-schedule the entire proposed construction program systematically in the light of all the interacting factors. Not the least of the problems to be

studied will be land-acquisition (condemnation) procedures and costs. Stockpiling (particularly of used and obsolete machinery) should be investigated (see the Reinhardt study on page 103).

Hundreds of other problems that are bound to come up in the course of a shelter-construction program should be studied so that they can be quietly solved if a decision to proceed is made.

Study of Communications: $500,000

We propose that $500,000 be spent to study the national-security aspects of communications during a war and in the recuperation period. In particular, the study should examine growth trends of U.S. communications and seek ways to exploit this growth to reduce the vulnerability of the system. This is one area in which the non-military defense program could make an important contribution to our military capability.

Study of Transportation: $500,000

This project should cover all forms of transport and should seek to determine measures that could be taken before hostilities that would help to restore transportation capabilities in the recuperation period.

CATEGORY V: SPECIAL EQUIPMENT AND PROCESSES ($15 MILLION)

Any non-military defense program will call for many new types of equipments--in fact, the creation of whole new technologies and techniques. We propose a research program to investigate solutions to many of the expected problems. The following is an incomplete but representative list of items that might be investigated:

(1) Excavating and tunneling (e.g., create and test new methods, new excavating machines, hauling equipment, drilling, blasting, etc.).

(2) Mass construction.

(3) Reinforced-concrete conduit extruded by continually moving equipment.

(4) Shock absorbers.

(5) Ventilation (needs, methods, problems when under attack, problems when shelter is isolated, broken-down equipment, etc.).

(6) Damage control (manuals, methods, training).

(7) Digging-out equipment for emergency use in deep shelters (e.g., develop non-oxygen-using equipment and perhaps stockpile special tunnel forms for use in digging out).

(8) Shelter utilities (define problems and study a wide variety of solutions, with particular attention to damage control).

(9) Non-food shelter supplies.

(10) Communication techniques.

(11) Storage and preservation.

(12) Postwar building technology (techniques of salvage and improvisation, plans for structures, manuals that show methods of using rubble and debris, etc., for building purposes).

(13) Gasoline substitutes for vehicles.

(14) Warning systems.

(15) Methods for rapid movement of masses of people.

(16) Blast doors.

(17) Stockpile connectors (nails, bolts, welding rods, etc., for connecting pieces of salvaged material).

(18) Clearing and cleanup (manuals, machines).

(19) Protected and shielded vehicles for moving people in contaminated

areas, particularly methods and materials for modifying conventional vehicles.

CATEGORY VI: ANTICONTAMINATION AND FALLOUT ($30 MILLION)

The greatest uncertainties we face in recuperating from a thermonuclear war seem to be connected with the aspects of fallout. It is crucially important that we eliminate these uncertainties if we are to avoid unpleasant consequences. Since many of the effects are long delayed, and because most of them can be studied only by extrapolation from low levels or from analogy-type experiments, it is important that this work be initiated as soon as possible. While there has been a vigorous program in the area, almost none of it has been directed toward the special kinds of problems we would face during and after a war.

The $30 million allocated to the study of fallout problems might be spent as follows:

Phenomenology of fallout	$ 5,000,000
Human, animal, and plant uptake of fission products	5,000,000
Human health hazards from fission products	5,000,000
Fallout countermeasures	13,000,000
Dosimetry research	1,000,000
Miscellaneous	1,000,000
	$30,000,000

The first three items roughly represent a 50 per cent expansion of the AEC's Sunshine Project for the next 2 years. (About $16 million was budgeted in 1957.) The aim of the study would be to provide a better understanding of the chain of events from the explosion of a nuclear weapon to the final evaluation of the health hazards resulting from the incorporation of fission products in humans so that the health problems could be predicted and controlled.

While much has been learned since the initiation of Project Sunshine in 1953, there are still important links in the chain that are poorly understood. Better data are needed on the distribution of the long-lived fission products among local, intermediate, and worldwide fallout for various conditions of weapon employment. A better understanding is needed of the residence times and distribution of fallout debris in the upper atmosphere in order to predict the resulting worldwide distribution. More study is necessary to permit prediction of the ultimate levels of strontium-90, cesium-137, and other fission products in humans for a given level of fallout in the soil. For example, estimates of the over-all discrimination factor for strontium-90 relative to calcium from soil to humans vary widely, and little is known concerning changes in availability of fission products to plants as a result of the weathering, cultivation, and fertilization of soils over long periods of time. Special dangers need be identified, such as human consumption of organs of certain animals in which radioactive substances are concentrated. Every one of the radioactive fission products must be studied in detail, not just the most dangerous, in order to predict all that can cause any trouble at high levels of fallout.

Data are also needed on the relation between levels of fission products in the body and bone cancer, leukemia, genetic effects, etc.

Research should be increased on methods for reducing the long-term health hazards to humans of high levels of fallout contamination. Because contamination levels resulting from weapons testing are very small and are likely to remain low, this area has not received as much attention as it deserves in relation to its potential importance for the recuperation effort following a large-scale nuclear attack.

We would seek to develop (a) methods for the control and decontamination of food and water supplies to reduce human intake of fission products; (b) farming methods to reduce concentration of fission products in the food supply; (c) methods of producing synthetic foods from uncontaminated raw materials; and (d) therapeutic agents that could be added to food to prevent retention of fission products in the body.

A research and development effort should be applied to the development of methods and equipment for large-scale decontamination of living and working areas, roads, etc. The use of vacuum cleaners, sweepers, bulldozers, scrapers, and washdown systems for this purpose should be investigated, as well as methods for disposing of the large quantities of contaminated debris that would result from these operations. Such measures, coupled with cheap efficient methods of shielding buildings, etc., could sharply reduce the total body radiation received by the population during the recuperation period.

The AEC's 1957 budget allotted less than $2 million for research in the above areas, and many of the individual items received no attention. The $13 million we have allotted to fallout countermeasures over a 2- or 3-year period is a large increase, but it does not appear excessive: $8 million may be spent by the AEC on one such project at a future Nevada test.

We are allotting $1 million to the development of cheap, rugged, simple, and reliable dosimeters and dose-rate meters that could be made widely available to families, civil-defense teams, police, schools, etc. (previously mentioned as an item to be included in the cheap civil-defense program discussed under Category I). Instruments capable of being used for the routine

detection of contaminated foodstuffs, water, etc., are needed, as well as equipment for surveying contamination levels of soils to determine which areas are suitable for agriculture. Most of the work has already been done by the AEC and FCDA. The $1 million we propose to spend over 2 or 3 years is a relatively small sum for supplemental research focused on the special problems of the storable "citizens meter."

CATEGORY VII: MEDICAL ASPECTS OF THE SHELTER PROGRAM ($10 MILLION)

Medical problems are second only to those of fallout in the uncertainty of our knowledge regarding them. Here, also, relatively little work has been done on the special problems of the war and postwar periods.

The $10 million for research in this area is provisionally allocated as follows:

1.	Study of communicable diseases	$ 1,500,000
2.	Study of the "existing medical load"	1,000,000
3.	Psychological and psychiatric studies	250,000
4.	Study of the mobilization of medical facilities.	250,000
5.	Study of the physiological aspects of shelters..	2,000,000
6.	Studies of very austere shelters and long occupations	1,500,000
7.	Study of acute-radiation therapy	2,000,000
8.	Study of postwar public-health problems.........	1,000,000
9.	Miscellaneous	500,000
		$10,000,000

Study of Communicable Diseases: $1,500,000

Since many diseases that are not provided with a suitable environment for spreading under ordinary circumstances might become serious problems in shelters, it is recommended that a study be made of all contagious diseases. Those shown likely to erupt in the shelter environment should be further studied. We could probably live with a large increase in the incidence of disease that just requires bed rest, but we don't want any catastrophes.

Diseases that come to mind are (a) all common respiratory diseases, (b) diptheria, (c) tuberculosis, (d) smallpox, (e) insect-borne diseases, (f) dysentery. Suggested expenditures are--

(1) Study and organization of relevant information already in existence and the monitoring of other research and coordination ($250,000).

(2) Respiratory vaccine research ($250,000).

(3) Antibiotic prophylactic studies ($1,000,000).

Study of the "Existing Medical Load": $1 Million

If it should ever become necessary to shelter a very large portion of our urban population, it would be desirable to provide medical care for those in need of it. Just how much and what kind to provide will be difficult to determine until more research has been done on the average medical load existing at various times in typical populations. Adapting this medical-care cross section to shelter conditions poses other problems (to be studied): special care of communicable diseases, more rapid ambulation of the bedridden, increased self-help therapy, etc.

Such a program might include the following projects:

(1) Study and organization of existing medical statistics, using several typical areas as samples ($150,000).

(2) Research on disease-carrier problems ($300,000).

(3) Research on rapid ambulation methods ($150,000).

(4) Research on "self-help" therapy and the use of relatively unskilled help in medical treatment and care. This research should result in the creation of simple "lay" kits and in the compilation and printing of manuals, and possibly the production of films ($400,000).

Psychological and Psychiatric Studies: $200,000

Various training programs concerned with the development of morale, leadership, etc., should be investigated. A study should be made of the preparation for family separation and of shelter techniques for handling this problem. It might be worth while to conduct preliminary research on the preparation of pamphlets, displays, films, etc., to be used both before entry into shelters (as part of a public-education program) and more importantly, afterward to acquaint people with their responsibilities and duties. Such materials would act as reassurance that the more unpleasant parts of the experience had been foreseen and judged to be bearable by a peacetime government.

Study of the Mobilization of Medical Facilities: $250,000

If we are to move large numbers of people into shelters, severe dislocations of our existing public-health and medical facilities may be expected. Mobilization plans should be studied with a view to minimizing these dislocations.

Study of the Physiological Aspects of Shelters: $2 Million

There is need to study the relationships between physiological needs and the structural details of shelters. Basic studies on air and ventilation, humidity, water, waste disposal, sanitary engineering in general, dietary needs, etc., are examples of subjects requiring investigation.

Studies of Very Austere Shelters and Long Occupations: $1,500,000

A study should be made of the survival of populations in environments similar to overcrowded shelters (concentration camps, Russian and German use of crowded freight cars, troopships, crowded prisons, crowded lifeboats,

submarines, etc.). Some useful guiding principles might be found and adapted to the shelter program.

Research projects might include:

(1) Study of available information that might suggest both reasonable standards and limits of human endurance, the latter to be used to determine overcrowding tolerances and for defining the early capability needed in personnel shelter studies ($200,000).

(2) Experimental environmental studies ($500,000).

(3) Investigation of the use of sedation and chemical tranquilization for long periods and for possible use in shelters ($800,000).

Study of Acute-Radiation Therapy: $2 Million

Emphasis should be placed on research seeking simple chemical preventives. Because people engaged in rescue and reconstruction work will be exposed to total body radiation, ways to ameliorate the effects are needed. The upper limits of controlled radiation exposure should be established for various situations. Protective measures, if found, would permit limits of exposure to be raised for emergency workers. Treatment for overexposure should be sought. Research is presently being done on this subject but should probably be expanded.

The research program might include:

(1) A search for and the screening of promising drugs that might prevent the acute radiation syndrome ($600,000).

(2) An investigation of human total-body-radiation limits, as an aid to establishing an upper range of emergency exposure ($600,000).

(3) A search for various therapeutic possibilities for treating the acute radiation syndrome ($600,000).

(4) A study of protective clothing and armor ($200,000).

Study of Postwar Public Health Problems: $1 Million

The early postwar years will involve, from the public-health point of view, the preservation of the health of people living under the adverse conditions of a rubbled and radioactive country and overcrowded housing. There will be increased patient loads and decreased medical facilities.

Research in this category should include:

(1) Plans for the rapid revival of water-purification systems, sewage-disposal systems, and food-inspection systems.

(2) Anticipation of the medical supplies needed for preventive medical problems (vaccine, vitamins, etc.).

(3) Plans for the administrative extension of surviving local sheltered units as the country rebuilds.

(4) Preparation for handling the problems caused by abnormal diets and food distribution, possible shortages of immunizing agents, insulin, etc. This research should include investigation of the concept of reconstituting the production and flow of these materials.

(5) Exploration of the possibility that all medical needs, especially with regard to hospitals, might require central administrative control.

(6) Details of the establishment of efficient emergency epidemiological units for the swift handling of potentially explosive infectious-disease problems.

CATEGORY VIII: FOOD AND AGRICULTURAL RESEARCH ($15 MILLION)

The sum of $15 million would be allocated to the following twelve projects:

1.	Food stocks	$ 1,000,000
2.	Survey of food-processing capability	250,000
3.	Processing as food those plants and crops not normally used for human consumption	250,000
4.	Shelter rations and survival diets	3,000,000
5.	Other food sources	3,000,000
6.	Food storage and preservation methods	2,000,000
7.	Crop studies	500,000
8.	Radiation protection of farmers, crops, and animals.	500,000
9.	Processing of foodstuffs to reduce strontium-90 content	500,000
10.	Land scraping and other fallout contamination measures	500,000
11.	Ecological research (widespread destruction of animal and plant life, charring of large areas, heightened mutation rates, flooding and fires, etc.)	2,000,000
12.	Miscellaneous	1,500,000
		$15,000,000

(Items 7, 8, 9, and 10 do not duplicate the studies of Category VI on fallout because the emphasis here should be on the economic and practical aspects of the measures rather than on analysis and research.)

Food Stocks: $1 Million

Seasonal information on stocks of food by type, quality, and location should be compiled. These data should indicate locations of food stocks, including those held by the Commodity Credit Corporation, by farmers, individuals, retailers and wholesalers, by restaurants, and by governments, as well as stocks in warehouses and in transit.

Work should be done on ways to decrease the vulnerability and increase availability of foods during and after attack and on the rapid expansion of agriculture to increase food stocks.

Shelter Rations and Survival Diets: $3 Million

Any complete shelter program is likely to call for at least 200,000,000 shelter spaces equipped with an average of 30 days' food supply per shelter space. (Some programs we examined call for a 90-day supply.) This means that saving 15 cents per day per person would reduce costs by about $1 billion. (It would only take about 5 cents per day per person to save $1 billion if we had a 90-day ration.) Most rations that have been proposed would run about $1.00 per person per day. We expect that one-third to one-half of this amount would be enough if some research were done (see the Carrier study on page 99).

Other Food Sources: $3 Million

An investigation should be made of algae cultivation, hydroponics, etc., as well as of emergency conversion of woodlands and grasslands to cereal crops, use of foreign lands, etc.

Crop Studies: $500,000

Crops having proper characteristics with respect to strontium uptake--root structures, calcium uptake, etc.--should be investigated.

CATEGORY IX: EXPANSION OF GOVERNMENT STUDIES ($10 MILLION)

Mobilization planning now costs about $10 million a year. We suggest adding this much more over a 2-year period and that there be some reorientation of the current work. Topics that might be studied are listed below:

(1) Defense uses of certain government activities, such as joint-use construction (schools, government buildings, highways), foreign-aid programs, and city and rural planning.

(2) Measures to subsidize non-military defense in various fields, such as protective construction, dispersal, decreased vulnerability, accelerated amortization of machinery (with agreement to dispose eventually to government or to store, so that used machinery could be obtained cheaply for stockpile), etc. Such measures would include direct monetary payment, tax amortization, tax penalties, and contract discrimination.

(3) Measures for the Starter and Recuperation Set, including short-term survival problems, emergency repair and patchup, contra-cyclical spending, marginal purchasing, trigger orders, various inventory policies, dispersed and/or protected warehousing, and the processing and bartering of current strategic stockpiles and of military and Commodity Credit Corporation stocks.

(4) Organizational and social problems of all types. For example, there is need for research on legal problems, on the training of cadres for shelters and movement control, on postwar political and economic problems, and on temporary and improvised cities.

(5) Special problems related to mobilization planning. Basic data should be collected and fundamental studies should be made, e.g., studies of national wealth, the role of the city, productivity (by type of plant and floor space, kinds of capital, etc.), and other census-type data. Among the many needed basic studies the following should certainly be included: economic, social, and political aspects of recuperation; economics of dispersal; war and deterrence; strategy of civil defense; and international organization of postwar world.

CATEGORY X: ACADEMIC STUDIES ($5 MILLION)

In studying so complicated a problem as non-military defense, it is important to tap as many intellectual resources as possible. We have previously mentioned the possibility of encouraging research work outside of government agencies at no cost (see Sec. I, suggestion 7). This should be supplemented by academic-type studies supported by research grants.

Academic studies might well be on some of the subjects mentioned immediately above in Category IX. A reasonable breakdown of the projects might be as follows:

250 (at $10,000 each)	$2,500,000
50 (at $20,000 each)	1,000,000
10 (at $50,000 each)	500,000
5 (at $100,000 each)	500,000
2 (at $250,000 each)	500,000
	$5,000,000

The $10,000 projects should result in a paper (about 6 man-research months). The $20,000 projects should result in a monograph or a book (1 man-research year). The $50,000 and $250,000 projects are team efforts.

CATEGORY XI: SYSTEMS ANALYSIS AND OPERATIONS RESEARCH ($10 MILLION)

In the non-military defense field an important deficiency exists in our understanding of performance versus cost of various systems under various circumstances and of the interactions between non-military defense and military defense. While this is not the place to engage in extensive polemics on the nature of systems analysis, we are recommending that a fairly large sum of money be spent in this field. More important, the success of the program is critically dependent on having "good" over-all studies. It might be appropriate to make some comments on some of the characteristics of a good analysis. The following is quoted from a RAND study on the techniques of systems analysis:(3)

"An item of equipment cannot be fully analyzed in isolation; frequently its interaction with the entire environment, including other equipment, has to be considered. The art of systems analysis is born of this fact; systems demand analysis as systems.

"Systems are analyzed with the intention of describing, evaluating, improving, and comparing with other systems. In the early days many people naively thought that this last meant picking a single definite quantitative measure of effectiveness, finding a best set of assumptions, and then using modern mathematics and high-speed computers to carry out the computations. Often their professional bias led them to believe that the central issues revolved around what kind of mathematics to use and how to use the computer.

"With some exceptions, the early picture was illusory. First, there is the trivial point that even modern techniques are not usually powerful enough to treat even simple practical problems without great simplification and idealization. The ability and knowledge necessary to do this simplification and idealization is not always standard equipment of scientists and mathematicians or even of their practical military collaborators.

"Much more important, the concept of a simple optimizing calculation ignores the central role of uncertainty. The uncertainty arises not only because we do not actually know what we have (much less what the enemy has) or what is going to happen, but also because we cannot agree on what we are trying to do.

"In practice, three kinds of uncertainty can be distinguished: (1) statistical uncertainty, (2) real uncertainty, and (3) uncertainty about the enemy's actions. We will mention each of these uncertainties in turn.

"(1) Statistical Uncertainty. This is the kind of uncertainty that pertains to fluctuation phenomena and random variables. It is the uncertainty associated with "honest" gambling devices. There are almost no conceptual difficulties in treating it--it merely makes the problems computationally more complicated.

"(2) Real Uncertainty. This is the uncertainty that arises from the fact that people believe different assumptions, have different tastes (and therefore objectives), and are (more often than not) ignorant. It has been argued by scholars that any single individual can, perhaps, treat this uncertainty as being identical to the statistical uncertainty mentioned above, but it is, in general, impossible for a group to do this in any satisfactory way.* For example, it is possible for individuals to assign subjectively evaluated numbers to such things as the probability of war or the probability of success of a research program, but there is typically no way of getting a useful consensus on these numbers. Usually, the best that can be done is to set limits between which most reasonable people agree the probabilities lie.

"The fact that people have different objectives has almost the same conceptual effect on the design of a socially satisfactory system as the disagreement about empirical assumptions. People value differently--for example, deterring a war as opposed to winning it or alleviating the consequences, if deterrence fails; they ascribe different values to human lives (some even differentiate between different categories of human lives, such as civilian and military, or friendly, neutral, and enemy), future preparedness

*L. J. Savage, The Foundations of Statistics, John Wiley and Sons, New York, 1954; K. J. Arrow, Social Choice and Individual Values, Cowles Commission Monograph No. 12, John Wiley and Sons, New York, 1951.

versus present, preparedness versus current standard of living, aggressive versus defensive policies, etc. Our category, 'Real Uncertainty,' covers differences in objectives, as well as differences in assumptions.

"The treatment of real uncertainty is somewhat controversial, but we believe actually fairly well understood, practically. It is handled mainly by what we call, 'Contingency Design.'

"(3) Uncertainty Due to Enemy Reaction. This uncertainty is a curious and baffling mixture of statistical and real uncertainty, complicated by the fact that we are playing a non-zero-sum game.* It is often very difficult to treat satisfactorily. A reasonable guiding principle seems to be (at least for a rich country) to compromise designs so as to be prepared for the possibility that the enemy is bright, knowledgeable, and malevolent, and yet be able to exploit the situation if the enemy fails in any of these qualities.

"To be specific:

- Assuming that the enemy is bright means giving him the freedom (for the purpose of analysis) to use the resources he has in the way that is best for him, even if you don't think he is smart enough to do so.
- Assuming that he is knowledgeable means giving the enemy credit for knowing your weaknesses if he could have found out about them by using reasonable effort. You should be willing to do this even though you yourself have just learned about these weaknesses.

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*The terminology "non-zero-sum game," refers to any conflict situation in which there are gains to be achieved if the contenders cooperate. Among other things, this introduces the possibilities of implicit or explicit bargaining between the two contenders. The whole concept of deterrence comes out of the notion that the game we are playing with Russia is non-zero-sum.

• Assuming that the enemy is malevolent means that you will at least look at the case in which the enemy does what is worst for you--even though it may not be rational for him to do so. This is sometimes an awful prospect and, in addition, plainly pessimistic, so one may wish to design against a 'rational' rather than a malevolent enemy; but as much as possible, one should carry some insurance against the latter possibility."

We hope that the above quotation illustrates in some measure what a difficult task it is to do a good systems analysis. Because technology and circumstances tend to change so rapidly, those persons who attempt to plan 5 or 10 years ahead are faced with a really difficult job. For further discussion on the kinds of trouble that can be encountered in systems analysis, see Refs. 3, 4, and 6 and other RAND studies on the subject.

Among the first things to be studied is how different kinds of non-military defense systems perform in various situations. We must design a preferred system in order to be in a position to exploit favorable circumstances and to hedge against unfavorable ones. Probably the worst defect of civil-defense studies today is that they have tended to concentrate on a single set of assumptions. As a result, their recommendations have not been tested against a large number of possibilities. The proposed analyses should not only consider a large range of circumstances but should also consider phasing problems, so that we will get early capabilities and still be able to accommodate growth in the future--particularly growth required by either unexpectedly large threats or by higher standards of habitability. Some of the problems that might be studied are listed below:

(1) Movement of the population to shelters, considering 10 to 50 minutes'

warning, 1 to 3 hours' warning, 10 to 20 hours' warning, and strategic evacuation.

(2) Various attack-response patterns. While attention should be focused on the case in which the enemy gets off a successful premeditated surprise attack, other cases should be explicitly considered, including preplanned and unpremeditated attacks, simultaneous attack, and the situation in which the enemy strikes second.

(3) Enemy tactics corresponding to three possible enemy target objectives: military, population, and recuperation--or mixtures of these.

(4) Civil-defense postures as influenced or determined by many contingencies, including variations in our own objectives or in those of the enemy, budget levels and allocations, disarmament, degrees of tension, changes in NATO, Chinese developments, other Russian satellite developments, etc.

(5) Other strategic and tactical considerations, e.g., sneak attacks and other unconventional tactics, unconventional weapons, reattacks, and the various ways war can terminate. Special attention should be paid to preparations that would facilitate a favorable end to the war by negotiation.

(6) The RAND study concentrated on the United States. A worldwide study should now be done.

(7) Certain basic technical uncertainties such as the performance and effects of weapons, carriers, air defense systems, medical unknowns, etc.

In addition, all studies should be conducted with a view toward understanding and exploiting interactions between military and non-military

defenses. Some areas in which these interactions occur, together with proposed research projects, are listed below:

(a) The circumstances in which wars can start should be examined to determine what roles can be played by augmentation abilities brought into play in tense situations, on D-day, or even after D-day. For the Starter Set our military prewar mobilization capability is important. Lastly, and most important, we must re-examine our capability of fighting for days or weeks.

(b) Civil defense contributes to the over-all problem by reducing the job of air defense and air offense to manageable proportions; by making large military budgets more acceptable (fighting and winning a war takes more military power than pure deterrence); by making the use of nuclear weapons in air defense safer; and by protecting important elements of our air defense and air offense capability.

(c) On the military side, air defense provides warning, increases the enemy's raid-size requirements (for even minimum-objective attacks), forces him to use expensive carriers and tactics, cuts down his force, increases his bombing inaccuracies, and may provide time against ICBM attacks by killing the first few missiles so that people can get into shelters.

(d) Air offense (and effective civil defense) forces the enemy to buy expensive defenses and, by making a U.S. first strike credible, draws his attacks (particularly his first strike) away from population and recuperation targets, ends the war quickly either by destroying the enemy or forcing him to negotiate, and complicates the enemy's job by providing dispersal, hardness, and alertness.

Appendix

A BRIEF SUMMARY OF THE BACKUP MATERIAL

1. PERSPECTIVE ON THE STUDY

Herman Kahn

The non-military defense study from which the recommendations and research program described in Secs. I and II emerged was broad in scope. It sought either to answer or define all the serious questions. Because the study was comparatively small, it could not look deeply into any one of these questions. The best we can claim for our results is that they are plausible. Many, possibly all, of the numerical results can be expected to change with further study. But even so, most of them should be better than the intuitive feelings and preconceptions almost everyone has at present.

If we were to enumerate the primary objectives of the study, they would be these:

(1) To achieve a better understanding and description of the components of non-military defense and of complete and balanced systems.

(2) To describe the research and development needed to improve the state of the art in all facets of non-military defense.

(3) Given objective (1), and conjectures about the results of objective (2), to obtain a better idea of the alternative means of attaining a useful non-military defense, and of the proper balance between military and non-military defense expenditures.

(4) To point the way toward easily achieved reductions in lead-time (probably 2 to 4 years over conventional programs) and costs for any non-military defense programs, large or small, that is adopted after objectives (1), (2), and (3) have been achieved.

(5) To indicate those preparatory actions that should be adopted soon so as to ensure the inexpensive acquisition of very important capabilities for use in the 1965-75 time period.

(6) To demonstrate that very modest and inexpensive measures (costing about $300 million), which could be instituted in a year or two, would probably save from 20 million to 50 million lives (depending on circumstances and the enemy's tactics), limit bonus and contingent damage, and markedly facilitate our ability to recuperate.

In addition to the eight suggestions described in Sec. I, which are proposed to implement our primary goals, we feel the study may provide payoffs:

(a) It may serve as a pilot study or to orient more ambitious studies or programs by the government and others.

(b) It may serve to eliminate misconceptions about how much damage a nation can suffer and not only survive but recuperate to roughly prewar standards in a relatively short time, i.e., in 5 to 15 years. From the viewpoint of survival and recuperation, the U.S. and Russia seem, at least on paper, to be much tougher than is generally thought.

(c) It may serve as the basis for new studies in the field of air defense and air offense. Most air defense studies have tried to devise systems to protect our mobilization base, and our population, with about 100 per cent certainty. They have failed, unless extremely unrealistic and optimistic assumptions are made. This type of assumption, in turn, leads to either unrealistic recommendations or to total apathy. Such studies tend to ignore the important things our defense and offense systems can do to alleviate the consequences of war. The opposing biases among those who study air defense--attempting too much, or nothing at all--show up in the official attitudes of the military groups charged with the defense mission.

Similar, but less intense, remarks can be made about our strategic offense capability, insofar as it is designed to deter and not to fight a

war. While deterrence of war must remain our defense establishment's most important mission, our non-military defense study indicates that there are important second-priority objectives and requirements for our defense and offense forces that are feasible but are not currently being met.

(d) In addition to the above payoffs, the study explored further the theory and practice of war and deterrence. We investigated the value of "long"-war (2 to 30 days) capabilities and the possible role of negotiation in terminating wars. (See "Conclusions" on page 107.) We also tried to distinguish clearly (and as quantitatively as seemed reasonable) between three types of deterrence.

<u>Type I: Deterring a direct Soviet attack on the United States</u>. The most relevant quantitative calculation is a Soviet one, in which it is assumed that the Soviets initiate the war and get the first strike. The United States then strikes back with a damaged force. After this counterstrike, the Soviets must ask themselves what damage have they suffered <u>and what further damage are they likely to suffer before they can terminate hostilities</u>. The existence and capabilities of even moderate Soviet civil-defense programs may be an important factor in Soviet calculations.

<u>Type II: Deterring extremely provocative S.U. behavior by the fear that the provocation might cause the United States to go to war.</u> The relevant calculation is again a Soviet one. In this calculation it is assumed that the United States strikes first and the Soviets strike back with a damaged force. United States warning problems are correspondingly simplified.

If the Type II deterrence fails and the Soviets go ahead with their extreme provocation, then the United States must now (a) determine what

damage she has suffered and is likely to suffer before hostilities can be terminated and (b) compare the risks of accepting the Soviet provocation, instituting military action, or using some temporizing measures. This last might range from a diplomatic protest to the U.S. evacuation of cities. Such an evacuation would greatly decrease the vulnerability of the United States and correspondingly increase its "objective" Type II deterrence and might thus cause the Soviets to back down or at least to compromise satisfactorily on the crisis that touched off the evacuation.

The calculations of the United States must always be tempered by the fear of touching off a "pre-emptive" Soviet attack--i.e., by the Soviet comparison of the risks of initiating a war versus the risks of doing nothing in the face of an increased probability of the United States starting a war.

Type III: Deterring moderately provocative actions. Quantitative calculations are less relevant here. Presumably the Soviets have to calculate gains versus losses. Their calculation might be influenced by the existence of a U.S. Starter Set, which makes explicit preparations for a crash U.S. non-military defense program. If a Soviet provocation touched off such a U.S. program, then the Soviets would probably be forced to strike, to try to match or counter this program, or to accept a position of inferiority. In all cases, the costs and risks to them as a result of their provocation have been increased. If this possibility is made explicit and probable, the Soviets might include these costs and risks in their calculations.

An important additional bonus of a U.S. civil-defense program is that it makes a stronger foreign policy more "rational" (because it decreases the risks). Making a stronger foreign policy more "rational" may or may

not make one more probable, but it certainly makes it more credible. This should help in deterring both Type II and Type III provocations.

2. WORLD REACTIONS

Leon Gouré

A U.S. civil-defense program will have several interesting international political implications.

INSURANCE

As long as the struggle for power between the western and the communist blocs persists, the possible occurrence of a major nuclear war cannot be ruled out, since even the threat of mutual devastation provides no ironclad guarantee against irrationality, political miscalculations, or error-free behavior by all who control or operate a nuclear-weapon capability. It may therefore be desirable to provide the United States with the capacity to fight such a war and to survive it.

DETERRENCE

The Soviet Union places great store in its military doctrine on a civil-defense program, because such a program increases its ability to survive a war if it has to fight; Moscow may very well look upon an equivalent American program as doing the same thing for the United States. This amounts to a strengthening of the U.S. deterrence posture, insofar as a civil-defense capability would strengthen our resolve to fight if necessary. Further studies are recommended to clarify how far such a program might affect the willingness of the United States to risk war in a crisis in which her vital interests are involved or at the least make it credible to the Russians that we would risk war. Such a credibility might deter the Russians from provocative behavior of an extreme type.

LIMITED WAR

In conflicts in peripheral areas the above arguments apply even more strongly. The risks of firmness are less and therefore a civil-defense program may have an even greater effect on the willingness of the United States to take military action. In addition, unless one believes that limited wars will always be self-regulating, it is necessary to institute soon the long-range program that may be required either to deter the enemy from exceeding the limitations or maybe even to be able to take corrective action if the limitations are exceeded.

NATO COUNTRIES

A U.S. civil-defense program is likely to have a beneficial effect on the strength of our alliances. Except for Canada and Great Britain, all of the NATO countries believe in the necessity for such a program and have at least a partial program in existence. They are therefore unlikely to look upon a U.S. civil-defense program as an act of weakness or isolationism. In addition, a U.S. civil-defense program would make it more rational for the United States to back the NATO countries in a crisis, and this might tend to reassure our NATO allies of our firmness in a crisis. If care is taken to avoid the appearance of a retreat to a "Fortress America" concept, the effect on NATO should be favorable.

3. SOCIAL PROBLEMS

Fred C. Iklé

In the following discussion only the more controversial issues among the many social problems of civil defense are examined.

PUBLIC APATHY

Public apathy is often thought to make any large-scale civil-defense program impossible. This notion exaggerates the degree of public participation that is necessary to get civil defense started. Much more dangerous is the attitude that we can and should devote all our efforts to make deterrence work. Since deterrence might fail for reasons beyond our control, we risk the total loss of our nation if we do not plan for this contingency.

STRATEGIC EVACUATION

A capability for strategic evacuation is eminently worth while, since it can--under various circumstances--greatly reduce casualties and facilitate recuperation. Experience from World War II and natural disasters shows that people do evacuate upon some kind of strategic warning and that they are willing to remain evacuated for some time in spite of hardships. In fact, strategic evacuation may become a voluntary, spontaneous reaction of the population to a threatening crisis (e.g., a deteriorating limited war), and the government should be prepared to take advantage of it. In certain international crises, moreover, the evacuation process may actually deter or reverse Soviet actions.

PANIC AND SHELTER LIFE

Panic, in the sense of irrational behavior detrimental to the individual, occurs rarely--as a rule only in confined spaces. It will, in general,

not be an important problem in strategic or tactical evacuation. However, shelter entrances and air-raid warning signals should be designed to minimize the risk of local panic. Prolonged confinement in shelters will unavoidably produce emotional stress. Various measures (work therapy, sedation, recreation, segregated activity or discipline areas, etc.) ought to be studied and prepared in order to maintain shelter discipline, to lessen the mental strain, and to minimize the incidence of psychological aftereffects.

POSTWAR POLITICAL AND SOCIAL STRUCTURE

The enormous deprivation and destruction of nuclear war could severely test our democratic institutions and breed political demagoguery or sectionalism. A well-designed civil-defense and recuperation program offers hope for the survival and rehabilitation of our political, social, and economic structure. Some schemes for property validation and compensation, such as the War Damage Equalization Corporation, can play a crucial role in the preservation of a capitalist free-market economy by restoring on an equitable basis, private property in the residual wealth of the nation and by encouraging the reconstruction of productive facilities through private financing and corporate ownership. In addition, certain simple and cheap protective measures for our political institutions and for independent news media can help keep the traditional democratic processes viable.

4. BALANCED NON-MILITARY DEFENSE PROGRAM

John J. O'Sullivan

A menu of balanced non-military defense programs is proposed. These are the result of preliminary study, and more intensive research and development effort is required before these programs can be specified accurately or final choices made.

Comprehensive non-military programs may be divided into three basic types:

(1) Protection of people and property from attack.

(2) Recuperation and reconstruction.

(3) The passive-defense Starter Set (a mobilization base, including stockpiles and detailed plans for a prewar crash program for non-military defense).

Although, conceptually, recuperation and reconstruction are distinct from the other programs, we have not treated them separately but have always included them in either the protection program or in the passive-defense Starter Set.

In this study we have considered four program levels--which are termed luxurious, austere, minimum, and cheap--for the protection and recuperation program, and two levels for the Starter and Recuperation Set.

These programs are intended to be balanced; we have tried to develop everything (personnel and industrial shelters, food and non-food stockpiles, and the miscellaneous categories, including research, development, etc.) to the same level of preparation or hardness.

It has been our intention, in setting up these programs, not only to balance them but to hold potential obsolescence or waste to a minimum if we happen to move from one program level to a more elaborate one.

It is quite likely that we have not balanced these items correctly. This would require much more work and resources than we gave to the problem. We consider our numbers as orienting and educational and not as estimates or recommendations.

The costs of the various programs are presented in the following table. The underlined numbers represent programs that are suggested for immediate implementation.

NON-MILITARY DEFENSE PROGRAMS
(Non-recurring costs in billions of dollars)[a]

Item	Type of Program					
	Protection and Recuperation				Starter and Recuperation	
	Luxurious	Austere	Minimum	Cheap	1-2 yr	2-5 yr
Personnel protection	80	35	5-20	0-1.0	0.3-2	0-0.1
Industry protection[b]	20	5	0.5-3	0-0.1	0.2-5	0-0.1
Food stockpiles[c]	30	4	0.5-3	0-0.1	0.0-1	0-0
Other supplies[d]	10	4	0.5-2	0.25-0.6	3-10	0-0.4
Miscellaneous	10	2	0.5-2	0.05-0.2	0.5-2	0.2-0.4
Total	150	50	7-30	0.3-2.0	4-20[e]	0.2-1.0

[a]We have not estimated maintenance costs, but we believe that they will be small compared with the programs.

[b]Much of this space is useable for personnel shelters.

[c]Does not include CCC stocks or current inventories.

[d]Does not include original cost ($7 billion) of strategic stockpile, war-reserve tools ($2 billion to $4 billion), or obsolete military stocks to be turned over to the civilian authorities.

[e]$20 billion includes an excellent strategic evacuation capability. $4 billion includes something better than the "cheap" civil-defense program but is not quite as good as the "minimum" program.

Briefly, the various protection and recuperation programs can be described as follows:

Luxurious: Very high standards of habitability and protection; in particular, this program is overdesigned as a hedge against the enemy's threat becoming worse or our reconstruction plans going awry.

Austere: A more or less conventional mix of blast and fallout shelters designed to minimal standards. In particular, this program lacks the insurance features of the luxurious program.

Minimum: Provides at least minimum protection against fallout to everybody.

Cheap: Wherever cheap protection is desirable, this program provides it.

The Starter and Recuperation programs are discussed in the Reinhardt study on page 103 and in Sec. II.

5. DEEP ROCK SHELTERS

Robert Panero

A detailed study was made of the problem of sheltering the population of Manhattan Island in deep rock shelters and of the requirements of shelters at such depths. The basic ground rules included 800-foot depth, a shelter space per person, entrances within 2000 feet (5 to 10 minutes' walking time) of everyone, and a 90-day occupancy with no critically important access to the outside world (living in a shelter can be likened to living in a submarine). This study was originally undertaken by the Panero firm and is being further extended by them for FCDA. Preliminary estimates indicate that the 90-day-occupancy costs of these deep rock shelters appear to be in the range of $500 to $800 per shelter space provided which is considerably cheaper than expected.

In order to determine the construction practicability of such a large excavation project, discussions were held with various construction and mining people who had worked at similar depths in the city of New York or its surrounding areas. Such shelters seem to be feasible. The whole system could probably be built in 5 or 6 years with conventional techniques.

As a result of the Manhattan study, and other studies on mines (reported separately; see page 101), the following table was prepared showing the costs of various kinds of deep rock shelters. While the table is rough, we believe it to be reasonably accurate.

COST OF VARIOUS DEEP ROCK SHELTERS
(Dollars per shelter space)

Type of Shelter	Length of Occupancy		
	2 days	7 days	30-90 days
Existing mine; horizontal access, excellent conditions	10-20	25-35	100-300
Existing mine; horizontal access, satisfactory conditions	20-30	30-50	200-400
Existing mine; slope access	100-200	150-300	200-500
Newly excavated site; horizontal access	....	150-300	200-400
Newly excavated site; slope access	....	200-500	400-800

NOTE: Costs vary according to local conditions, degree of protection, and habitability standards. These costs include everything except food, medicine, and real-estate acquisition.

6. EARLY ("CHEAP") NON-MILITARY DEFENSE CAPABILITY

Irwin Mann

There are a number of measures that, at relatively small cost, may achieve a capability of providing significant levels of protection to people, limit accidental or bonus damage to property, and facilitate rapid recuperation.

(a) Fallout shelters for joint war and peace use, utilizing construction already existing, could be identified, improved, or devised. Identification would consist essentially in finding the best existing or most easily modified protection for both evacuees and the local population. Once identified, these buildings could be designated by some simple system. The improvement could be by means of sandbags, shutters, or other methods, either before or after the attack, wherever it seemed desirable or cheap. Since by the nature of fallout most areas would get 2 to 10 hours' warning (and in some probable tactical situations much more), these improvements, if prepared for in advance, could be emplaced after the first attack. In addition, mines, sewers, caves or other special structures might be found for fallout protection. The mines look particularly promising in many areas. (See the Panero study on page 101).

(b) Inexpensive radiation meters of simple design could be made available throughout the country. Such meters would help to protect people during the acute radiation hazard and would be invaluable as a recuperation aid, since it will be necessary to monitor and control the radioactive environment for some time after the attack. Without these meters, it is likely that restoration would be very difficult, if not paralyzed.

(c) Detailed plans should be made for both damage control (shutdown of utilities, abandonment of factories and cities, etc.) and emergency patch-up and repair. The latter should include local plans for decontamination, perhaps using manuals similar to those developed by NRDL for military bases. The resources developed in points (a) and (b), above, should be exploited for this use.

(d) The capability to evacuate cities on short notice could be improved. Points (a), (b), and (c), above, should be coordinated with these plans. Evacuation would mostly be to a distance short enough (20 to 50 miles) to provide a reasonably dispersed population target (see the Ross-Reinhardt study on page 83). The improvised fallout shelters could be most concentrated in such a "ring." Some personnel might be left in the city, in the best shelters available, for minimum maintenance requirements and to help limit bonus and contingent damage, such as from fires.

(e) A strategic evacuation capability could also be planned; this plan should include a means for improvising fallout shelters on short notice.

(f) The warning system for civilians could be made more reliable and complete.

(g) Provisions could be made to ensure better exploitation of existing civilian and government inventories in the event of an attack. We have not estimated the costs of doing this, but the government stocks are large, as is shown in the table below:

Material	Approximate Cost ($ billion)
Strategic raw materials	7
War-reserve tools	2-4
CCC stocks	6
Obsolete military stocks	(?)

It would probably be worth while to spend some money to make these stockpiles more useful.

(k) The organizational and legal basis for civil defense could be improved.

(l) Once the government has entered the civil-defense field in a serious way, and has provided the possibility for some kind of protection for almost everyone, it should be easy to induce some significant number of people to provide for better protection on their own. A combination of education, technical assistance, and "show piece" shelter prototypes might be very effective.

It is suggested that the above measures constitute a reasonable and balanced program. These are not only valuable interim measures, but the capabilities bought will provide a legacy for any later and larger program. The cost breakdown might be (approximately):

$300 MILLION "CHEAP" PROGRAM

Meters	$150,000,000
Shelter survey	20,000,000
Shelter supplies	60,000,000
Evacuation	20,000,000
Prototypes	20,000,000
Education and assistance	20,000,000
Miscellaneous	10,000,000
	$300,000,000

7. MOVEMENT PROBLEMS

Frank Ross and George Reinhardt

The study considered two distinct problems: (1) the U.S. national transportation network's capabilities, vulnerability, and postattack recuperability, and (2) mass movement of the population, taking into consideration varying conditions of warning, distances to be moved, and types of transportation.

The capability and the method of computing it were determined by obtaining an estimate of peacetime capacity. While the study of the response to attack did not progress to the point where specific bills of goods were moved, it did indicate that enough capacity would survive so that after patchup there should be no problem in meeting the presumably reduced demands of the postwar period. Bottlenecks to recovery will probably not occur in rights-of-way but only in equipment and maintenance. It may be desirable, therefore, to stockpile spare parts, or perhaps better, spare assemblies. Since later attacks are likely to present a much more severe problem a more careful study than the one we did should be made.

The problems involved in evacuating 20 to 90 per cent of urban populations long distances (or only to fallout shelters) by rail, motor vehicle, and combinations of the two were studied. Results indicate that great improvements would be attainable by prior planning, preparations, and model test runs. Simplification of movement directives is urged; such directives could cite St. Louis, Milwaukee, and Cincinnati as cities having "typical" programs for urban areas. In the study, this was applied to the situation in Los Angeles. To remedy the prevailing claims of an inadequate road net, it is suggested that the use of existing facilities be improved. It is

believed that in most cities it would be possible to evacuate a majority of the population to a fallout-shelter belt (25 to 40 miles) in 3 hours. The mechanics of evacuating Los Angeles was studied in detail.

8. MEDICAL EFFECTS OF RADIATION

Harold H. Mitchell, M.D.

A study of the postattack radiation environment indicates that survival is possible if plans are made to control the radiation dosage received by people. The most critical problem is controlling the short-term, high dose rates to which people might be exposed.

Human experience suggests that short-term body exposure should be kept below 200 roentgens. Since recovery rates may be discouragingly low, intermediate total dosages may well have to be kept within the same bounds. Time does buy some recovery and hence some increase in total body radiation allowable for the same effect, but this cannot yet be predicted quantitatively with any assurance.

Cumulative total dosages may best be evaluated in terms of a general decrease in life span or as an increase in death rate for the whole population. A reasonable interpretation of human and animal data, at present, suggests that 10 per cent life shortening per 1000 roentgens of total body radiation may be used as a standard for evaluation of the long-term radiation problem. For the normal life span of 70 years this would be about 2-1/2 days per roentgen for exposure of children and less for exposure of adults. More research in this area is urgently needed.

It has been estimated that for each 50 roentgens' exposure to each parent there may be an increase of one in a thousand in the number of harmfully affected children in the next generation as a result of dominant mutations. Recessive mutations will come to expression over very many generations. Eventually most of the harmful genes should be eliminated by the process of natural selection. Although the grand total of genetically

damaged individuals will be large, the concentration at any one time will be relatively small and will be a manageable increment added to the ever-present natural problem.

The deposition of strontium-90 is accepted as the most serious of the internally deposited radionuclides. It is suggested that between 10 microcuries and 100 microcuries in a "standard man" is the range between onset of bone cancer and serious difficulty with large numbers of cancer cases. This is an opinion derived from scaling up current concepts regarding the maximum permissible concentration and human damage occurring in radium cases. The current relationship between the amount of strontium-90 in the environment and in new bone indicates that very large numbers of weapons must be detonated before serious bone levels will exist. This is true even if we don't allow for the possibility of using mitigating measures. However, since strontium-90 works its way into bone over the lifetime of the individual, time is clearly available for the application of mitigating measures.

9. LONG-TERM FALLOUT PROBLEMS

Jerald Hill

The long-term fallout hazards from total body radiation and the ingestion of strontium-90 and cesium-137 have been estimated for two levels of attack on the United States. Attack I assumes 151 surface-burst bombs yielding 1510 MT of fission products; attack II, 1200 surface-burst bombs yielding 20,000 MT of fission products. It was assumed that 80 per cent of the total activity was deposited on the U.S. land area.

The average dose rates of total body radiation 3 months after attack, reduced by a factor of 100 to allow for decontamination, shielding, weathering, etc., would be 0.26 and 3.7 times the current maximum permissible levels (MPL) for industrial workers, for attacks I and II, respectively. The maximum dose rates under the same conditions would be only 5.6 times the MPL for attack I and 24 MPL for attack II.

Since more than 85 per cent of the U.S. land area would experience dose rates of less than average for attack I, it is clear that a population that is both sheltered from the early fallout radiation and that is prepared to carry out mitigating measures would easily be able to survive the long-term radiation levels.

For attack II possibly less than 50 per cent of the U.S. land area would experience dose rates of less than average, so that much more extensive use of decontamination, shielding, and radiation control of personnel would be required to keep the long-term dose levels within acceptable limits. However, survival in this case also appears completely feasible.

The average strontium-90 levels, in terms of the maximum permissible concentrations (MPC) currently allowed for industrial workers, would be 2

and 26 MPC for attacks I and II, respectively. The maximum strontium-90 levels would be 42 MPC for attack I and 180 MPC for attack II. Since the MPC has a safety factor of 10 before serious incidence of bone cancer, and since countermeasures (e.g., consuming crops with minimum uptake of strontium-90, maximum use of crop land with less than average strontium-90 content, chemical treatment of soils, water treatment, supplementing diets with uncontaminated calcium, etc.) could probably reduce the strontium-90 intake by a factor of 10 or more, it is clear that strontium-90 bone cancer would not prevent survival of the postwar population. Research and development to achieve economically feasible countermeasures should be augmented and accelerated.

Cesium-90 contamination levels are almost twice the corresponding levels for strontium-90, but the much smaller biological uptake, smaller elimination times, and a 90 times higher MPC make the cesium-137 ingestion problem much less serious than that of strontium-90.

10. AIR OFFENSE (SOVIET UNION AND UNITED STATES)

Harry Rowen

Our strategic force defends our population and economy principally by deterring general war. However, its contribution does not end there, for if deterrence fails, SAC can help to defend our cities in three ways: (1) by forcing the diversion of limited Soviet long-range forces to attacks on SAC to prevent our retaliation; (2) through counterforce attacks on the Soviet strategic force; and (3) by a combination of (1) and (2) to gain time for the civil population to take advantage of passive defenses.

The extent to which our strategic force could reduce the weight of attack on our cities is uncertain. If we have a well-protected power to strike back and a moderate counterforce ability, and the enemy nonetheless starts the war by attempting to destroy SAC, very little of his long-range forces would be available for attack on our cities. If, however, our SAC is not well protected, or if the Soviet Union responds to our civil-defense program by increasing the size and protection of its strategic-delivery capability, sizable forces could be reserved for attack on our cities.

There are other ways a war might start apart from a deliberate initial Soviet strike. For example, the existence of increasingly alert strategic forces on both sides increases the chances of accidental outbreak of war. However, for a war that might begin in this fashion, enemy attacks would probably be less well designed and our active and passive defenses might perform better than we would expect them to against a well-designed deliberate attack.

11. AIR DEFENSE: INTERACTION OF ACTIVE AND PASSIVE DEFENSE

Philip M. Dadant

Some of the important interactions between passive defense and warning and active defense were reviewed in this study.

Passive defense and warning: The essential ingredient of passive defense is shelters or evacuation to shelters. Simple fallout shelters may require no warning prior to bomb detonation, since it takes time for the fallout to come down. Shelters for blast protection require warning time adequate to get people into the shelters before bombs arrive. Even more warning might permit dispersal from target areas. A capability for sheltering would force the enemy to use more bombs to produce a given effect. In some circumstances this might give us a better chance to achieve more warning because of increased delivery time and increased preparatory actions.

Total warning time must not be mistaken for effective warning time. Early warning is usually of an equivocal nature and will generally not allow non-repetitive actions to be taken.

Active defense and warning: Active defense increases raid size, which means better likelihood of early warning and less equivocality of the warning. Hence active defense helps to ensure the warning time needed to get people into shelters. However, active defense itself needs warning if it is to be highly effective.

A combination of warning measures and active defenses adequate to raise the minimum number of attackers above the threshold of detection and recognition by the warning system is essential to ensure SAC's deterrent capability. Most measures taken to aid SAC also help to provide warning for cities under many kinds of attacks, but perhaps not all.

How active defense helps passive defense: Active defense reduces the number of bombs on target through attrition. It forces the attacker to limit the number of targets attacked. If defense weapons are deployable during battle, the defender may save some valuable targets at the expense of letting others be overkilled. Attrition helps to hold fallout down, particularly if bombs are shot down over water or far from targets. Active defenses may destroy the accuracy of the attack by deflecting warheads, creating combat degradation, and enhancing the likelihood of gross errors. The enemy may partially overcome this, but at the expense of carrying fewer bombs or building more expensive systems, which will subtract from the size of his force. The enemy may attack defenses, but every bomb on a defense target is one less on another target.

Perhaps most important, active defenses force the attacker to use decoys and electronic and tactical countermeasures, which not only decreases his warhead payload and drains his resources, but prevents him from using "free ride" tactics. The necessity of having to saturate defenses increases the enemy's requirements for staging bases, launchers, or launch crews in order to achieve simultaneity of attack.

How passive defense helps active defense: The establishment of shelters and stockpiles for recuperation may change the target system to collections of small, hard targets. When this is true, the enemy will need bigger bombs and better accuracy, which will reduce his payload available for countermeasures and subtract from his total resources. These requirements may postpone the date when ICBM's are judged to be adequate, thus allowing more time to develop an ICBM defense. Isolated hard targets are easier to defend because near misses can be ignored. Hard targets may permit the use of large

defensive warheads at close range, which will be particularly important in allowing the atmosphere to filter out ICBM space decoys.

Most importantly, the existence of passive defenses may make the goal of active defense feasible by increasing by a large factor the number of bombs that can be tolerated.

Tradeoffs between active defense, passive defense, warning, and offense: Active defense, passive defense, warning, and offense all interact with one another and all vie for money from the same budget. The tradeoffs should be examined and appropriate combination of these measures should be determined before large passive-defense expenditures are committed.

12. EVALUATION

Leonard Berkovitz

Civilian casualties resulting from an attack on the United States would be a function of the attacker's strategy and tactics as well as of our own civil-defense measures. For example, if it is assumed that the attacker's strategy would be first to strike mainly at SAC, then the particular tactics used would depend on the strength and posture of SAC and on our air-defense capabilities. The more protected SAC is by hardening and dispersal, the greater will be the weight of the attack that is presumed to be diverted to it. In the study, various civil-defense measures were evaluated in conjunction with different SAC postures. While the table on page 96 is very approximate, we believe that the numbers are accurate enough to provide some degree of orientation.

The attacker's option is the major uncertainty in civil-defense measures for the protection of populations. For example, even with a hard SAC, an attacker could increase the casualties beyond the ranges indicated above should he choose to give up rather small military advantages. The calculations given in the table may not allow for the full range of options available to the attacker; therefore, the problem needs more study.

A strong civil-defense program could conceivably strengthen our deterrence of extremely provocative actions on the part of Soviet policymakers who do not want war but who are willing to engage in provocative or testing actions short of war. These policymakers would have to concede to themselves the possibility of an accidental start of war or that the United States might strike first in the light of the provocation. With the full civil-defense program, U.S. casualties under these circumstances should be

in the 3 million to 10 million range; this figure, relative to the casualties that the Soviets could expect, might magnify the risks of provocative action in Russian eyes, and thus deter it.

CONCEIVABLE NEAR-FUTURE ATTACK AGAINST SAC
AND FIRST 50 URBANIZED AREAS

Civil-defense Measure	Casualties (millions)
None	90
Minimum fallout	30-70[a]
Minimum fallout plus 70 per cent strategic evacuation	5-25

CONCEIVABLE LATER FUTURE ATTACK AGAINST SAC
AND 157 URBANIZED AREAS[b]

Civil-defense Measure	Casualties (millions)
None	160
A complete program:	
Protected SAC	8-25[c]
Unprotected SAC	40-55
70 per cent strategic evacuation:	
Protected SAC	3-5
Unprotected SAC	12-20
Minimum fallout:	
Protected SAC	65-85
Unprotected SAC	over 85

[a]Where ranges are given, the particular value in the range will depend on the tactics of the attacker.

[b]In the unprotected SAC cases, attacks extend to targets beyond this list to cities in the 25,000 to 50,000 population category.

[c]In this case, the lower figure is for an attack on SAC only in the first 45 minutes; the higher figure assumes that the enemy gives up a slight military advantage and attacks a few population targets with the opening missile salvo.

13. RECUPERATION AFTER A NEAR FUTURE ATTACK

Paul Clark

This portion of the study considered the question: Is economic recuperation feasible after a plausible near-future attack? The attack assumed is sufficient to destroy all productive capital in about fifty of our most important metropolitan areas. A rough quantitative calculation was made, which focused on problems of capital balance and new capital formation. The analysis was based on a table relating total national capital to gross national product (GNP) by way of nine sectors, and on the assumption that output in each sector would be limited initially by surviving capital and later by postattack investment.

In the first year after reorganization, it appears that surviving capital would permit a GNP of 50 to 60 per cent of the preattack level, with per capita consumption at a sustainable level. A major bottleneck is indicated in the capacity to produce new durable goods. It appears that GNP could be restored to its preattack level after about a decade of reconstruction, though recovery would be much affected by the choice between a consumption-oriented and an investment-oriented policy in the first few years.

A sensible order of priority for preattack policies to ease recuperation might include the stockpiling of construction materials for patching up partially damaged capital; preserving normal inventories of metals, building machinery, and materials; and sheltering complete plants in the durable-good industries.

14. FOOD PROBLEMS

Joseph Carrier

A brief survey of the surviving population's minimum needs suggests that enough inventories and industrial capacity would be available, even after a successful attack on 100 standard metropolitan areas, to supply consumer goods for the first year. The problem considered here is the post-attack supply of food. Greater attention was focused on food because of its prime importance for meeting minimum consumer needs. The current quantity and dispersal of food inventories, plus the fact that they will not be permanently contaminated by fallout, indicate that an adequate supply should be available for the first year. The food supply for the following years should also be adequate if only, say, 53 standard metropolitan areas are attacked, leaving large areas of cropland uncontaminated by fallout. But if attacks are made on more targets and with greater weapon yields, enough croplands may be contaminated to cause concern over the level of radioactive contamination in the population's diet for a year or two.

Plans for the first year following the attack should include the development and testing of a shelter ration, and perhaps an interim ration for the period when the population leaves the shelters but normal food supplies aboveground are not available. Rations that would be practical from a cost or physical standpoint have not been created for either shelter or interim use. Survival and emergency rations used by the Armed Forces are costly and are not designed to be used by a population for survival. From a cost standpoint, for example, an army survival ration costing 75 cents per person per day would mean a total ration cost of $150 million per day. Based on a minimum-cost diet, a suitable shelter ration might cost no more

than 40 cents per person per day, a saving of almost 50 per cent, which would certainly make research in this area worth while.

The objective for some years following the attack should be to keep levels of contamination in the diet low. This might be accomplished as follows: (a) Import food from abroad or from non-contaminated areas where grasslands and pasture lands could be converted and yields per acre could be increased to provide greater quantities of food; (b) decontaminate crop lands and discriminate against strontium-90 in the growing of food crops and the ingestion of food; and (c) Before the attack, stockpile unprocessed foodstuffs that could supplement or replace the populations' diet.

Perhaps a sensible civil-defense food program would be a 3-month stockpile of food in the shelters plus a long-run stockpile containing at least several years' supply of synthetic vitamins and low-calorie high-protein foods. This seems feasible in cost and time and would lower the population's intake of strontium-90, allowing time for discrimination techniques to be put into effect.

15. AVAILABILITY AND POSSIBLE USES OF MINES

Robert Panero

This portion of the study attempted to give a general description of the types of mines that can be considered for military, civil defense, or industrial installations. The results were based on studies originally developed for the Department of the Army and extended, on a consulting basis, for RAND, by the staff of Guy B. Panero Engineers. Mining operations that lend themselves to underground installations were examined. Various ways in which mines can be developed were analyzed.

By means of a sampling procedure and some judicious guessing, the 1948 census of floorspace available in suitable mines was brought up to date. It was concluded that there should be 750,000,000 square feet of such space.

In terms of military uses, such as SAGE control centers, or civilian uses, such as storage or protection of people, these suitable mines can be readily adapted. In terms of industrial installations, much more work needs to be done before even rough estimates of the relevant costs can be made. It is believed that with imaginative design rather than the mere placing of surface installations underground, construction and operation will generally be comparable in cost to that aboveground.

Possible research and development programs in terms of future underground installations were spelled out in some detail, indicating the type and size of studies that might prove of value.

The study concluded that underground space could be ordered in advance by various means; that if ordered in advance, such space should be available very inexpensively through minor operational changes in the applicable mining industries, and that in terms of military and civilian use, such space could well become an important national asset.

16. STARTER AND RECUPERATION SETS

George Reinhardt

The purpose of the "Starter Set" is to put us in a position where we can, if necessary, achieve a complete civil-defense program within a year or two. This means that we could attain a "hard" passive-defense posture for population and for some industry. (Such a program, without this preparation, would require 5 to 6 years to achieve.)

The "Recuperation Set" is designed to expedite national recovery after a nuclear war, particularly if such a war comes before the Starter Set has been established. Both the sets also provide significant passive-defense capability in themselves.

The features of the Starter and Recuperation Sets are explained by analogy with preparations for a major construction project, indicating that several years of lead-time and costly errors can be eliminated through preparatory low-cost research and design efforts. Further, time and dollars can be saved through the relatively inexpensive, partial procurement of certain materials and equipment selected to reduce bottlenecks discovered by advance studies.

For purpose of illustration only, $20 billion and $3 billion budgets for the expensive stockpile components of a combined Starter and Recuperation Set, covering, respectively, twelve and five major items, are outlined on page 104.

Even smaller budgets might be valuable if we knew enough about the mobilization capabilities of our economy to select the really critical items. Clearly, more research is required for developing and evaluating the whole concept of Starter and Recuperation Sets, and for detailing the means for their implementation.

$20 BILLION AND $3 BILLION BUDGETS FOR COMPONENTS OF A COMBINED STARTER AND RECUPERATION SET

	$20 Billion Budget	$3 Billion Budget
Cement	$1.0 billion	$0.5 billion
Corrugated steel	2.0 billion	0.8 billion
Reinforcing steel	1.0 billion	0.8 billion
Structural-steel shapes	0.5 billion	....
Construction and special equipment (new and used)	1.0 billion	0.4 billion
Processing strategic stockpiles	1.0 billion	....
1.5 billion square feet of subsidized and partially equipped mine space .	1.5 billion	....
Outfitting 1.5 billion square feet of subsidized and partially equipped mine space	3.0 billion	....
Private factories subsidized	4.0 billion	....
Partial and standby plants	2.0 billion	0.5 billion
Transportation stockpile	1.0 billion	....
Miscellaneous stockpile	2.0 billion	....
	$20.0 billion	$3.0 billion

17. RECUPERATION AFTER A LATER FUTURE ATTACK

Norman Hanunian

On plausible assumptions about the development of Soviet offense and U.S. defense, it is at least conceivable that an attack in the more distant future could cover 200,000 or 300,000 square miles with blast forces strong enough to collapse practically all structures of conventional design. The great bulk of our economy is located within just such an area.

So far, we have only inadequate knowledge of what high levels of destruction imply about the course or likelihood of recuperation. If we want to increase our confidence about the prospects for recovery, we must improve our defenses. It seems feasible--both in the technological and the economic senses--to do this by "hardening" structures. However, the costs of hardening, though uncertain, are likely to be large. This is evident from brief consideration of manufacturing, a sector of the economy that currently generates nearly one-third of our national income. We may posit, by way of illustration, that we shall be satisfied if hardening promises to prevent a medium-sized attack--say one on about 100 metropolitan areas--from destroying more than 60 per cent of any major manufacturing industry. Since some industries are relatively dispersed as they presently exist, this end may be attainable by hardening as little as one-fifth of our manufacturing capital. Such a program might cost $30 billion.

This is not a very confident estimate. It could easily be off, in either direction, by more than a factor of two. (Data presented in the Panero underground installation study discussed on page 77 even suggest that it might be possible to devise an equivalent program that would be costless.) The lack of experience with underground plants is a considerable

handicap in evaluating such measures. Our judgment in combining what seem to be the appropriate elements of mining practice, plant design, and location theory may quite possibly be faulty in important respects.

In any event, we should, when suitable data becomes available, try to determine the effect of larger attacks on requirements, and we should do this in conjunction with certain refinements in the criterion by which installations are selected for hardening.

18. CONCLUSIONS

Herman Kahn

There is a general belief today that an all-out thermonuclear war would be totally annihilating--so annihilating that nothing useful could be done to mitigate its consequences. This reflects itself in the phraseology of deterrence--"balance of terror," "suicidal war," "mutual annihilation," "inescapable end of civilization," "destruction of all life," etc. Those phrases are reinforced by the common deterrence analogies--"two scorpions in a bottle," "two people seated on a single keg of dynamite with two buttons," "two heads on a single chopping block," "the bee which dies when it stings," etc.

We feel that the major result of the present study is that we have demonstrated that, subject to uncertainties, the above view is wrong, for at least the next 5 or 10 years, and probably for a much longer period. We did this by showing (in a somewhat tentative fashion that should be verified by a more complete study) that--

1. There are a number of combinations of military and non-military measures that will provide valuable levels of protection. While the level of protection will vary with the cost of the program, the kind of attacks that are analyzed, and the assumptions used in the analysis, it is a fair, if slightly inaccurate, summary to say that we can protect about half the people of the United States with high confidence, one-fourth with medium confidence, and one-fourth with low confidence. During the time period of interest to the study, the cost of satisfactory measures varied because the enemy's threat varied, but we indicated that it should be possible

to put in a phased program that would be reasonably effective during the whole 1960-70 time-period. This phased program would start with the cheap civil-defense program (described in the Mann study on page 79), go into the "minimum" program, and end with the "luxurious" program (described in the O'Sullivan study on page 73).

2. The use of shelters with long-occupancy time and anti-contamination should make it possible to handle the acute-radiation problem (first 3 months) from even the worst attacks.
3. With only moderate preparations in the early time-period and more elaborate ones in the late time-period, it should be relatively easy to handle the short-term survival (3 months to 2 years) and patchup and repair problems.
4. With the right combination of military and non-military measures to protect enough capital, the economy could be restored to about half that of prewar levels in the first year. In addition, the recuperation to prewar levels might be much faster (5 to 15 years) than has been generally supposed. In any case, if reasonable measures are taken it is very difficult to imagine that the economy will go (on a per capita basis) below 1930-40 levels.
5. Long-lived radioactivity problems, while quite serious, could be alleviated, so that in comparison with the direct effects of the war, they would have a relatively minor impact on the economy or on the expectations and happiness of the <u>average</u> individual.
6. A similar statement can be made for genetic effects, even though these may last a thousand years. This last statement, of course, is only true if we have a single war. We did not investigate the

effect of repeated wars (i.e., wars occurring every few generations), but we would guess it to be close to disastrous.

Once the proposition that "it is possible to alleviate the consequences of a thermonuclear war" is accepted, it will be necessary to decide if it is worth while to spend money on such a capability. Because we believe that it is very implausible to imagine that war has been abolished by the invention of fission and fusion weapons, we have gone into some detail to indicate why both fighting a war or being able to stand up to the threat of war is of the highest importance. (See the Kahn and Gouré studies on pages 63 and 69.)

Because a war is so horrible, it takes an act of imagination to visualize one's starting. It should not take a further act of imagination to believe that it will end. If one or both sides are unprepared, it is likely to end by the almost total destruction of the military forces of one side by the other in a few hours. If, however, both sides have prepared to fight a "long" war--a war of at least a few days' duration--then it is difficult to see how the military forces themselves can be totally destroyed. This means that the war should end by surrender or negotiation.

Certain tactics facilitate a quick and favorable end by negotiation. For example, the attacker can avoid the defender's cities and use the threat of destruction of these cities as a hostage to the defender's good behavior. and as an inducement to his negotiating or surrendering. Similarly, the defender can use the threat of his surviving forces to compel the attackers to offer "reasonable" terms.

No matter what scenario is imagined, the ability of the offense and defense to survive for days is most important. Nevertheless, most writing

on military planning for new strategic systems seems overly concerned with wars that last less than 1 day. If we are seriously interested in alleviating the consequences of a war, then we are interested in having military capabilities--both offensive and defensive--on the second and third days of the war. In fact, we believe that sensible military planning would provide for wars lasting from 2 to 30 days, though the first day (or even the first hours) of the war is likely to be of the utmost significance.

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